AN INVESTIGATION OF COMMUNICATIONS MANAGEMENT AND CONTROL REQUIREMENTS AND THEIR POSSIBLE APPLICATIONS TO THE MTACCS TACTICAL DATA SYSTEMS

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THESIS

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THEIR POSSIBLE APPLICATIONS TO
THE MTACCS TACTICAL DATA SYSTEMS

by

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March 1981

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	An Investigation Of Communications Mangement And Control Rrequirements And Their Possible Applications To The MTACCS Tactical Data Systems
5. TYPE OF REPORT & PERIOD COVERED	Master's Thesis; March 1981
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	Donald C. Mahler
8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Naval Postgraduate School Monterey, California 93940
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS	Naval Postgraduate School Monterey, California 93940
12. REPORT DATE	March 1981
13. NUMBER OF PAGES	97
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Marine Corps Communication Control; MTACCS/LFICS Interfacing; Marine Corps Communications Management; Marine Corps Command and Control

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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This thesis examines the impact of that enhanced capability with particular emphasis given to the management and control of the

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S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1981

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The Marine Corps Tactical Command and Control System (MTACCS) is expected to significantly enhance the decision making capability of tactical commanders. The Landing Force Integrated Communications System (LFICS) provides the data communications for this capability.

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I. INTRODUCTION

Modern warfare has become so intense and so lethal that correct and timely decisions by the commander are essential for survival and ultimate victory. The necessity of making large numbers of such decisions over an extended period of time appears to accurately describe the nature of the problem facing the commander and his staff in any future conflicts.

Responding successfully to intense actions requires concentration of intense firepower under which rapid maneuvers can take place. Selective concentration of firepower with maneuver elements requires accurate and timely identification of targets and initial selection of weapons systems and ordnance, while maintaining the momentum of continuous attack. Command and control (C^2) must be effectively employed to achieve this goal. To accomplish this in the 1985 time frame and beyond, the Marine Corps has initiated the development and acquisition of the Marine Corps Tactical Command and Control Systems (MTACCS). Component systems of MTACCS along with their logical interfaces and information flow requirements are discussed in Chapter III of this thesis.

A communication systems architecture designated the Landing Force Integrated Communications System (LFICS) has been designed to provide the high-speed, high-quality data communications network to support the MTACCS tactical data

systems. This support is envisioned to be in the form of message and circuit switched networks that will provide the real-time information exchange capability.

MTACCS and LFICS amount to a revolution in capabilities. With the increased rapidity of telecommunications and the potential for increases in volume and accuracy of information flow up and down the chain of command, it is not unreasonable to expect change. Indeed, with the increased reliance on common, automatic switched networks for transfer of command and control information, the probability of changes in the command and control structure, authority, and responsibility at various command levels increases substantially. Communications units will be affected the most, but all units can expect some changes. Chapter III of this thesis discusses the degree of change in the command and control structure as envisioned by the author. Chapter IV presents changes required in the communications system to support the new command and control structure.

The intent of this thesis, then, is to examine the role of the Marine Corps telecommunication manager in planning for the employment and systems management of an integrated MTACCS/LFICS architecture. Current doctrinal communications support and communications control procedures, as outlined in Fleet Marine Force Manual (FMFM) 10-1 will be subjectively evaluated to determine changes in communications support,

communications doctrine, and organizational structure needed for effective employment and responsive management of the automatic message and circuit switched networks.

II. THE STRUCTURE OF THE CURRENT C^2 SYSTEM

A. ORGANIZATION OF THE COMMUNICATIONS SYSTEM

1. A Systems Approach

The current vogue in describing large, complex organizations is to use the systems approach. In this approach to an organization, the total system is a set of elements that are united by some form of interaction or interdependence in seeking a common goal. Orlicky's definition [Ref. 1], is particularly good when applied to a military system. He says:

> "A system is a composite that functions as an entity, and its main attribute is that its utility, or power, is greater than that of its components summed individually."

The total system for the purposes of this discussion is a Marine Air-Ground Task Force (MAGTF), of Marine Amphibious Force (MAF) size, with all of its diffuse units and functions. Each of the units and support functions is considered as both a subsystem and an entity, and as such has interests in its own right. The units are united by the common goal of accomplishing the mission assigned to the tactical organization, and are linked together by a network that organizes the total system into a coordinated pattern. These essential links, which permit parts of the system to interact with each other and the external environment are a subset of, and make up a communications system. In the military tactical

environment, the communications subsystem provides the means of exercising tactical command, operational control, administrative processes, and logistical functions for the total system and within each subordinate unit.

2. The Communications Subsystem Concept

The concept of a communications subsystem for an organization is a very broad one and, in fact Murdick and Ross [Ref. 2], feel the total system can be represented by its communications functions.

The Marine Corps communications subsystem will be referred to as the "communications system" with the understanding that it is not the top of the hierarchial levels. The communications system can be defined as the organization, activities, and equipment that are required to electrically transmit and receive information within and external to the total system along with any processing incident to the transmission, reception, and distribution to the user. Simply stated, the communications system is a technical network that provides the means for interchange of information.

Because of the Marine Corps' concept of employment, any specific hardware configuration of the communications system is a relatively temporary network, capable of being installed in almost any location in the world. It uses little in the way of fixed-plant facilities and can be reconfigured completely in a short period of time. Because its primary mission is to support combat operations, the

system must be highly adaptable and flexible. In this context, then, and for the purposes of this discussion, communications is considered to be a supporting service; intelligence, a class of information; and automated data processing, a capability for facilitating information handling, computation, and display. The term command and control will implicitly encompass all of the above functions.

3. The Structure Of The Communications System

The organizational structure of the communications system is dictated solely by the organization of the unit it supports. The Marine Amphibious Force (MAF) command structure, depicted in Figure (1), is composed of one or more Marine Divisions (DIV), one or more Marine Aircraft Wings (MAW), and one Force Service Support Group (FSSG). There are three infantry regiments and one artillery regiment in each division. The regiments are composed of battalions which are the smallest self-supporting combat units. The organization of the MAW is variable with a headquarters group, a service group, an air control group, and two or more Marine aircraft groups (MAG) being the usual arrangement. The FSSG consists of Combat Service Support (CSS) battalions and includes a headquarters and service battalion, maintenance battalion, engineer support battalion, supply battalion, landing support battalion, motor transport battalion, medical battalion, and a dental battalion.

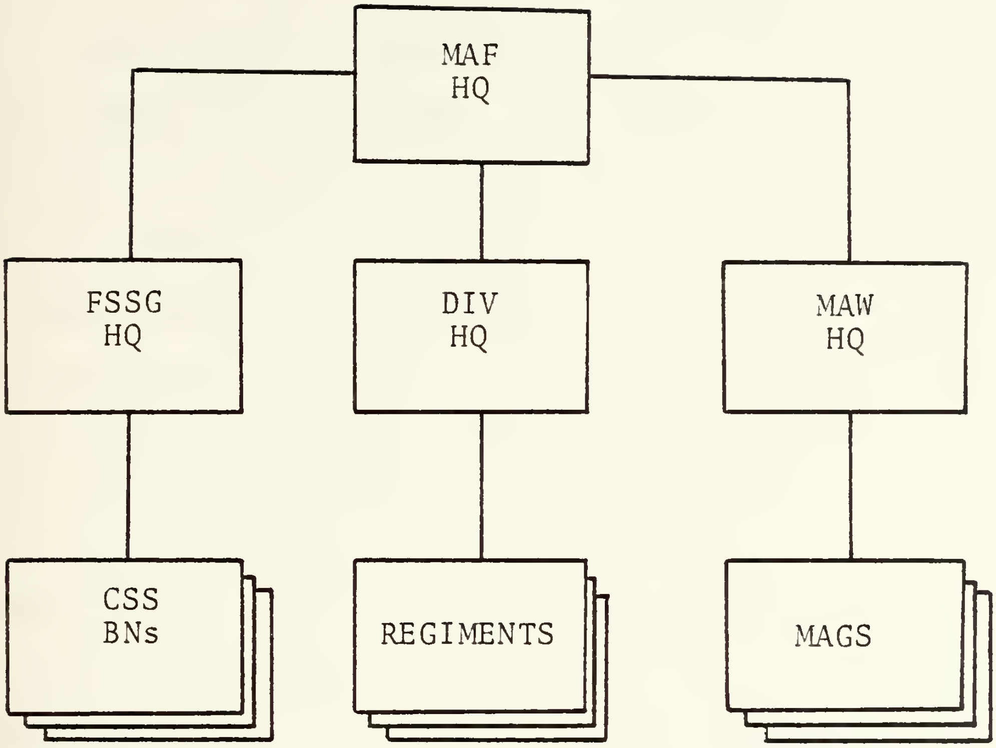


Figure (1) MAF Command Structure (Partial)

The MAF communications system follows this structure and each of these levels has a communications organization and a communications management function that are subsystems of the communications system. The communications system extends below the group and battalion levels in the form of users, but there are no management functions involved. At each higher level in the organization, the communications system becomes larger, more complex, and more difficult to manage simply because the organization supported is larger and the mission is broader.

B. THE CURRENT TACTICAL COMMAND AND CONTROL STRUCTURE

Marine Corps command and control (C^2) is a hierarchial organization. As with any hierarchial structure, there is a requirement for communications and flow of information both up and down the chain of command. Likewise, the command and control system and the communications supporting it emphasizes the vertical order of senior/subordinate relationships. Simply stated, the chain of communications follows the chain of command. Figure (1) succinctly represents the hierarchial interface between the force commander and his three major subordinate commander.

The traditional JCS definitions of command control and a command and control system are as follows:

"Command control is the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of his mission."

"A command and control system is the facilities, equipment, communications, procedures and personnel essential to a commander for planning, directing, and controlling the operations of assigned forces persuant to the mission assigned." [Ref. 3]

While these are useful definitions for some purposes, they do not adequately differentiate the two separate and distinct functions. Command is simply the exercise of authority, the execution of which is generally the issuance of an order. Command systems should therefore be considered as any means for delivering the proper order to the proper subordinate at the proper time. Before a commander can take any rational further action, however, he needs to know that the order was in fact received and when it was received. He must know how (or if) and when his orders were carried out, and he must know what end effect his orders had on the status and position of both the enemy's forces and his own. Thus, the notion of control in the tactical sense is directly analogous to the feedback control loop used in electrical circuits. Obviously the delays built into the tactical control loop are longer, but failure to minimize those delays or to take them into account can have the same effect as in electrical circuits: positive rather than negative (corrective) feedback, leading to instability, oscillation, and/or outright failure. Control systems, then, can be considered to be any means for sampling the output of command systems so as to influence the inputs.

Lawson [Ref. 4], points out an item of central importance concerning the command and control functions. He states:

> "...each level of command must also have the capability to provide direction, set objectives, and to exercise override controls on the lower levels as the situation dictates."

These controls for the purposes of this discussion include not only the coordination of warfare activities and the allocation of supporting weapons systems, but also the management and tasking of sensor and communications assets and the state of the lines of information and control flow as well.

Thus, it becomes increasingly clear that one of the most important tasks for a commander is to set goals or desired states for his subordinate commanders (the command function), and to monitor the interface between his subordinates as their common superior (the control function). Figure (2), extracted from Greinke [Ref. 5], is a representation of the traditional interlocking characteristics of tactical C^2 at various echelons of command within a typical MAGTF. At the infantry battalion and below maneuver elements, the strike-oriented command and control functions dominate, with the control function as the predominate capability. Moving up through the chain of command, the command function becomes more predominate, although control still remains very important in a feedback-loop sense. The effect of automation relative to this traditional command and control structure will be discussed, in part, below, and expanded on in Chapter III of this thesis.

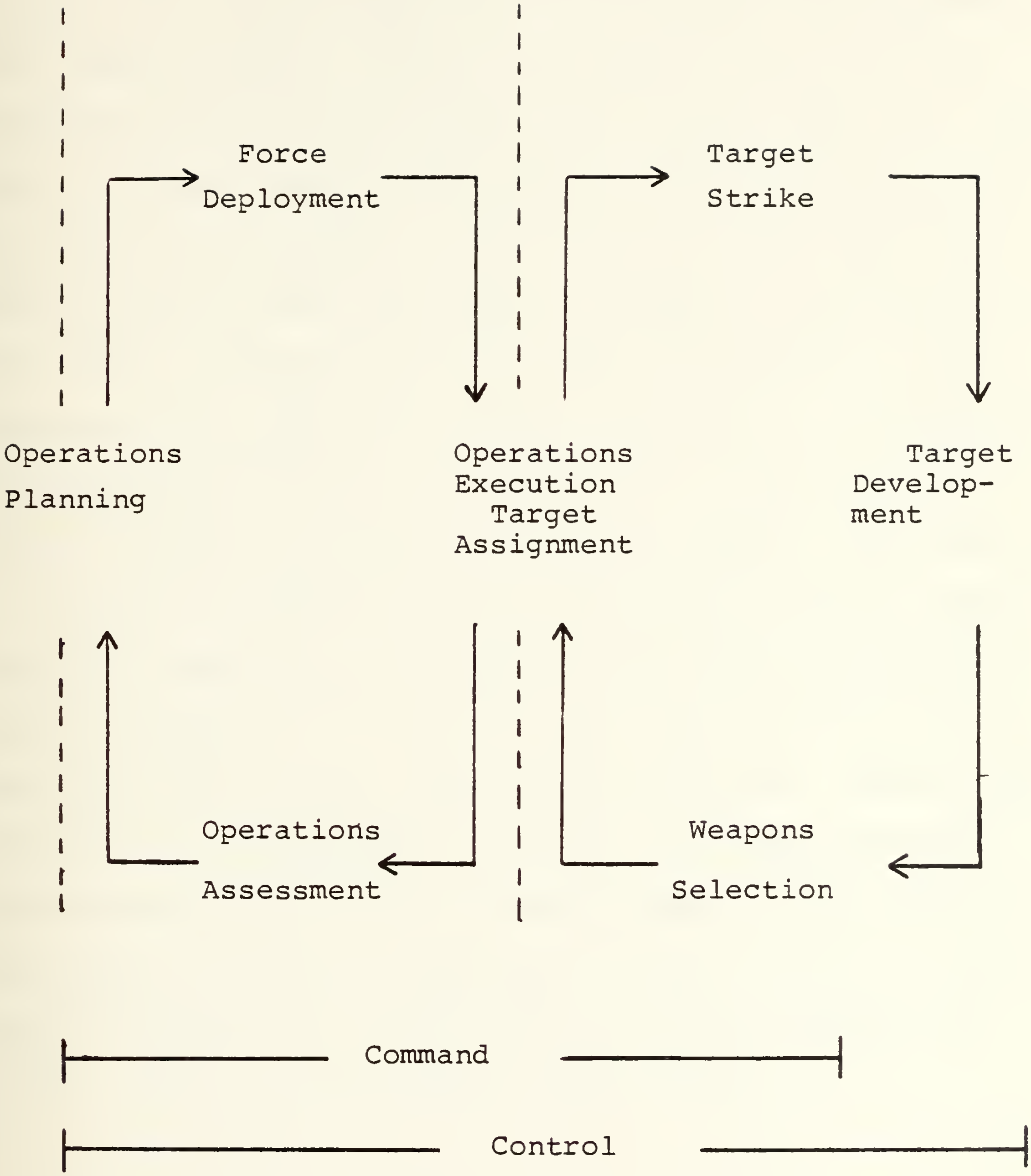


Figure (2) Tactical Command and Control Interfaces and Characteristics

C. THE ROLE OF TACTICAL COMPUTER SYSTEMS

Much has been written concerning the role that automated systems will play in support of battlefields of the future; their speed, unerring accuracy and ability to process vast quantities of raw data being the only way the human can cope with the lethal weaponry and complexities of modern warfare. Little has been written however, concerning the impact of computer-based command and control systems on the separate functions of command and control and the functions of the communications system that provide connectivity. Changes in the command and control structure will inevitably result because of the automation factor. For example, when Figure (2) is applied to automated command and control systems, characterized by inherent query/response and automatic information transfer capability, it appears that support of the control function is the primary purpose for automation. Indeed, the argument may be made that the control function, previously accomplished at the strike-oriented command levels, may be preempted by superior commanders through increased control function information and drive the automated command and control structure to de facto centralization.

III. THE STRUCTURE OF THE FUTURE C^2 SYSTEM

A. BACKGROUND

1. The MTACCS Concept

Systems that will support the Fleet Marine Forces in the mid-1980 time frame are being developed under the Marine Tactical Command and Control Systems (MTACCS) concept. The MTACCS concept was initially proposed by studies conducted in the mid-1960's to determine the feasibility and practicality of applying new technology to command and control of Marine combat forces with the overriding objective of providing commanders with the command and control means necessary to cope with the increased tempo and complexity of the post-1980 battlefield.

MTACCS itself is not a program, but rather a concept. The design concept calls for maximum commonality of equipment, operational procedures, data bases and extensive interoperability through a common communications subsystem known as the Landing Force Integrated Communications System (LFICS).

The Marine Corps' approach to developing the MTACCS concept was to define functional systems that could be grouped together through standardized hardware, software, and protocol techniques to form a fully integrated command and control system. The systems of interest to this thesis along with their expected implementation dates are listed as follows:

. Marine Integrated Fire and Air Support System (MIFASS)-1986.

. Tactical Combat Operations System (TCO) - 1986.

. Position Location Reporting System (PLRS) - 1982.

. Tactical Air Operations Central-1985 (TAOC-85) - 1985.

. Marine Air-Ground Intelligence System (MAGIS) - 1983.

. Marine Integrated Personnel System (MIPS) - 1986.

2. <u>MTACCS Interoperability Requirements</u>

A primary objective and major requirement of all the MTACCS tactical data systems is the need for interoperability. This need encompasses interoperability among individual systems as well as other service and NATO systems. As pointed out in the MTACCS Master Plan:

> "The capability to interoperate must be at a level that does not degrade the ability of other U.S. Service/NATO units to support Marine Corps units or vice versa." [Ref. 6]

Examples of interoperability requirements are:

. MAGTF and subordinate element headquarters must be able to interoperate with Army/NATO corps, division, and brigade headquarters.

. Marine Corps and Army artillery headquarters and firing units must be able to interoperate in combination.

. MAGTF and subordinate headquarters must be able to interoperate with amphibious task force command and control agencies such as the supporting arms coordination center (SACC), and the tactical air control center (TACC) afloat.

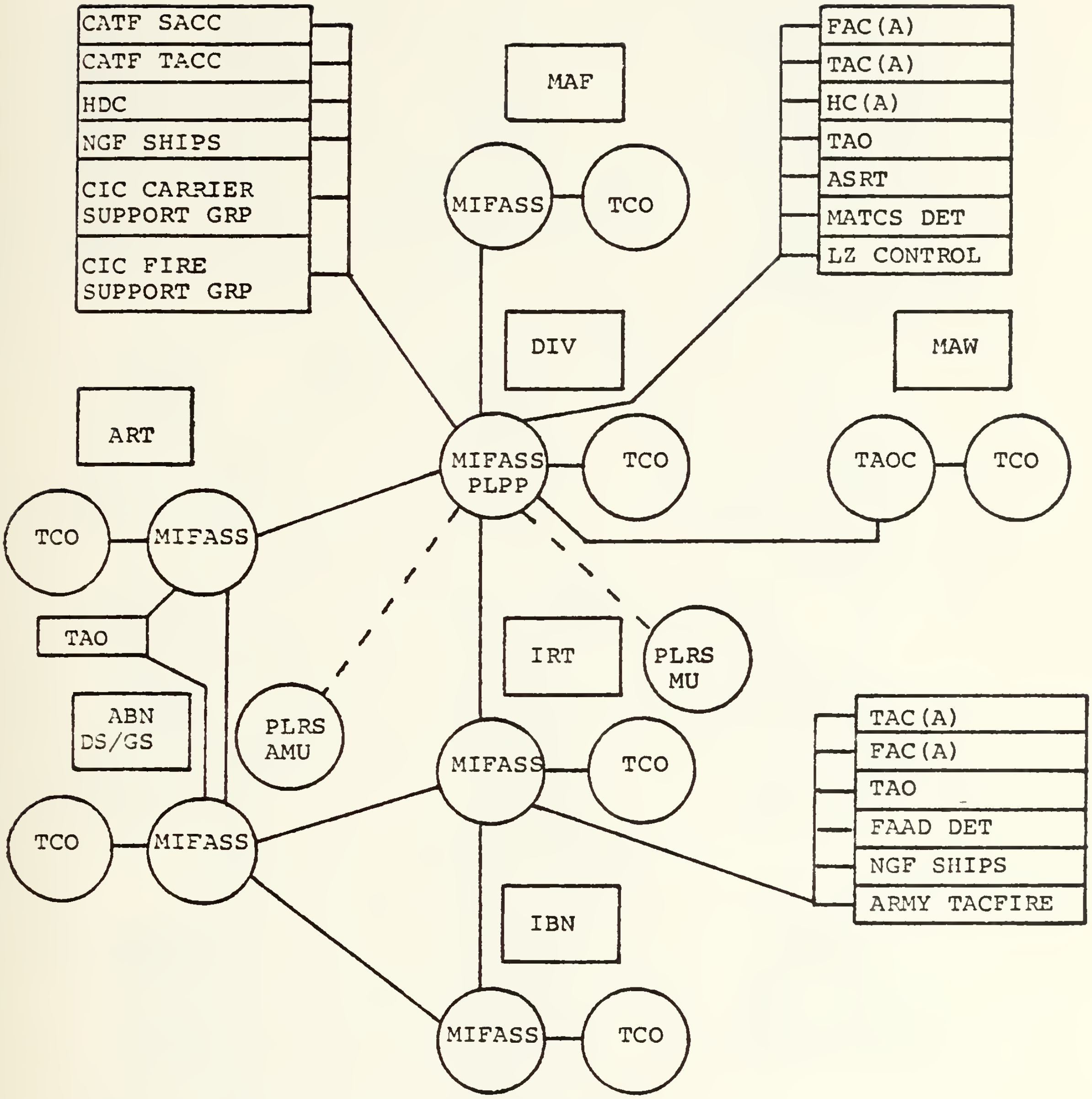
Maximum integration of ground and air tactical data systems is required to enhance the combat power of a MAGTF. Interoperability among TCO, MIFASS (including PLRS position location information processed through the Position Location

Post Processor), MAGIS, and TAOC-85 is a fundamental requirement. This will be accomplished through hardware modularity, which provides the capability to interchange hardware modules responsible for peripheral, power, and protocol interfaces; through software standardization; and through a common circuit and message switched network provided by LFICS.

Other important air-ground interoperability areas include TCO and TAOC-85. Quoting from the MTACCS Master Plan, "These air-ground areas must be developed with the goal of ensuring the continuity of information flow" [Ref. 7]. For example, direct air support aircraft track data provided by TAOC-85 must be readily correlatable by the MIFASS Position Location Post Processor (PLPP) track data should the aircraft be PLRS equipped.

MIFASS, as a command and control system, is the point of greatest air-ground interface. Direct Air Support Center (DASC) functions, previously accomplished by a separate aviation agency, will be incorporated into the MIFASS system located at the division headquarters. Rapid and reliable information flow between MIFASS and TAOC-85 is required for optimal employment and control of close air support aircraft.

Figures (3) through (9), extracted from the MTACCS Master Plan, depict the information flow and interfaces required of each system. A feature not readily apparent in the Figures is the logical/virtual circuit capability that will



MIFASS Logical Links

PLRS/PLPP PLI Input (Centralized PLPP)

Figure (3) MIFASS Logical Interfaces And Information Flow

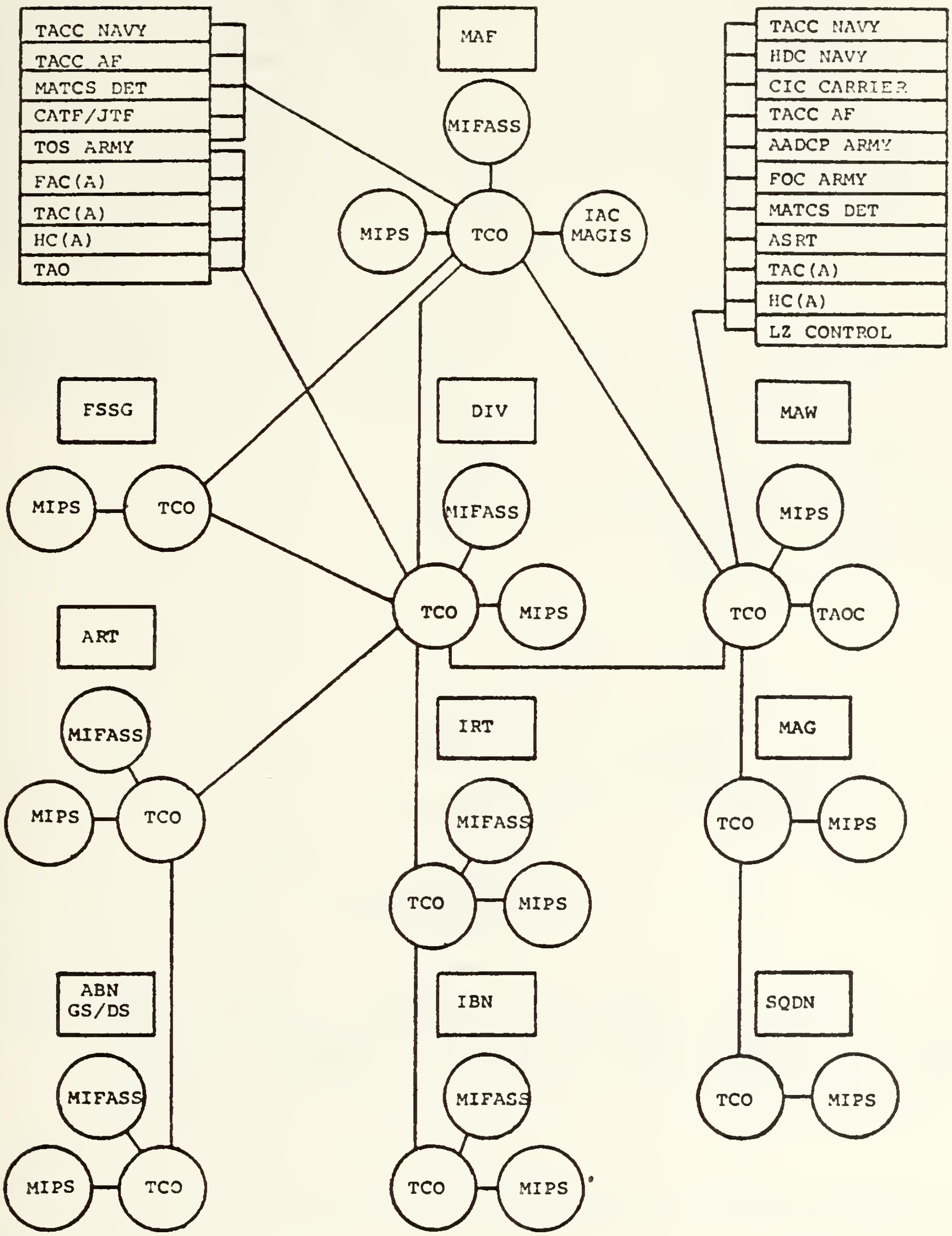
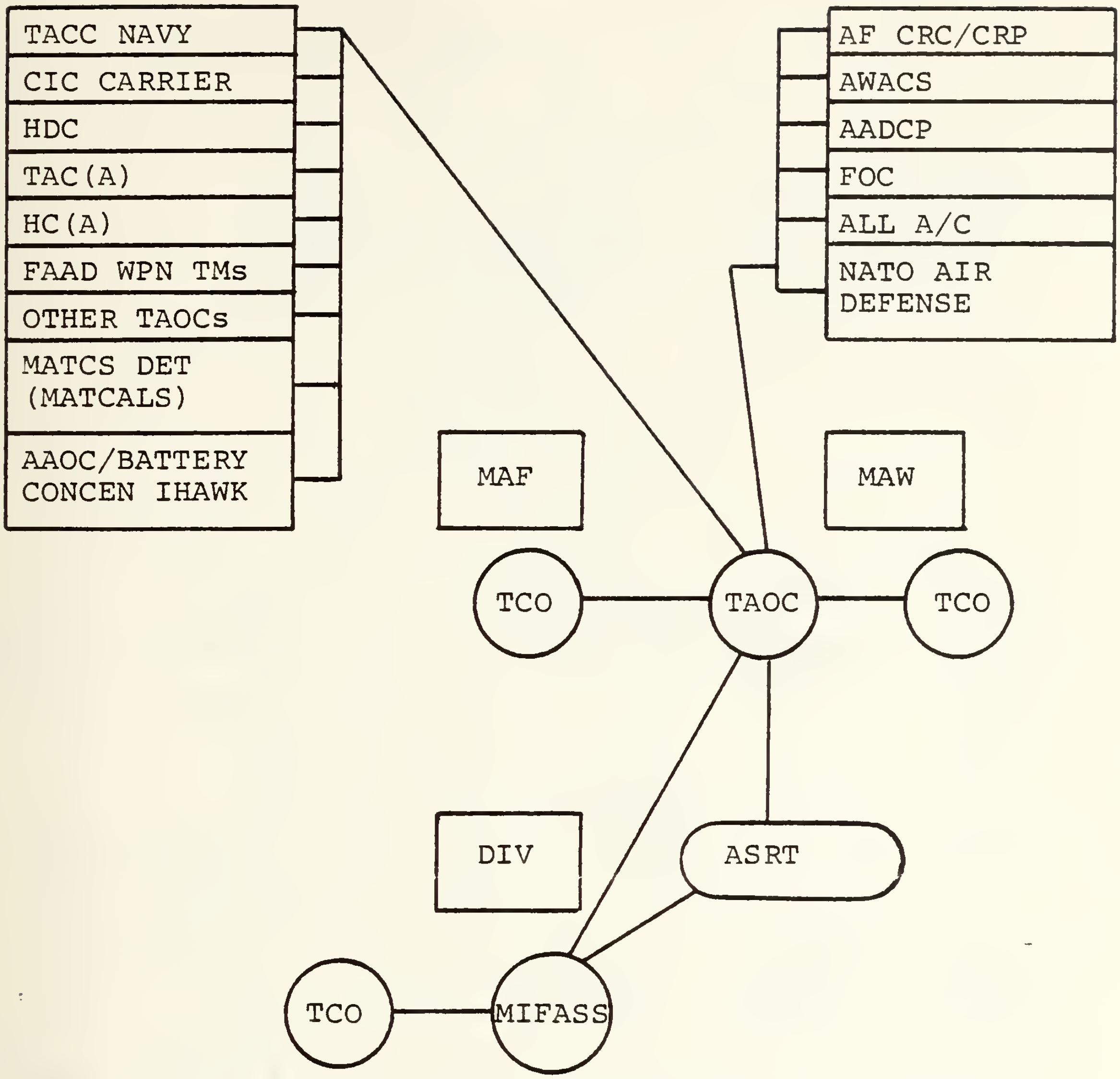
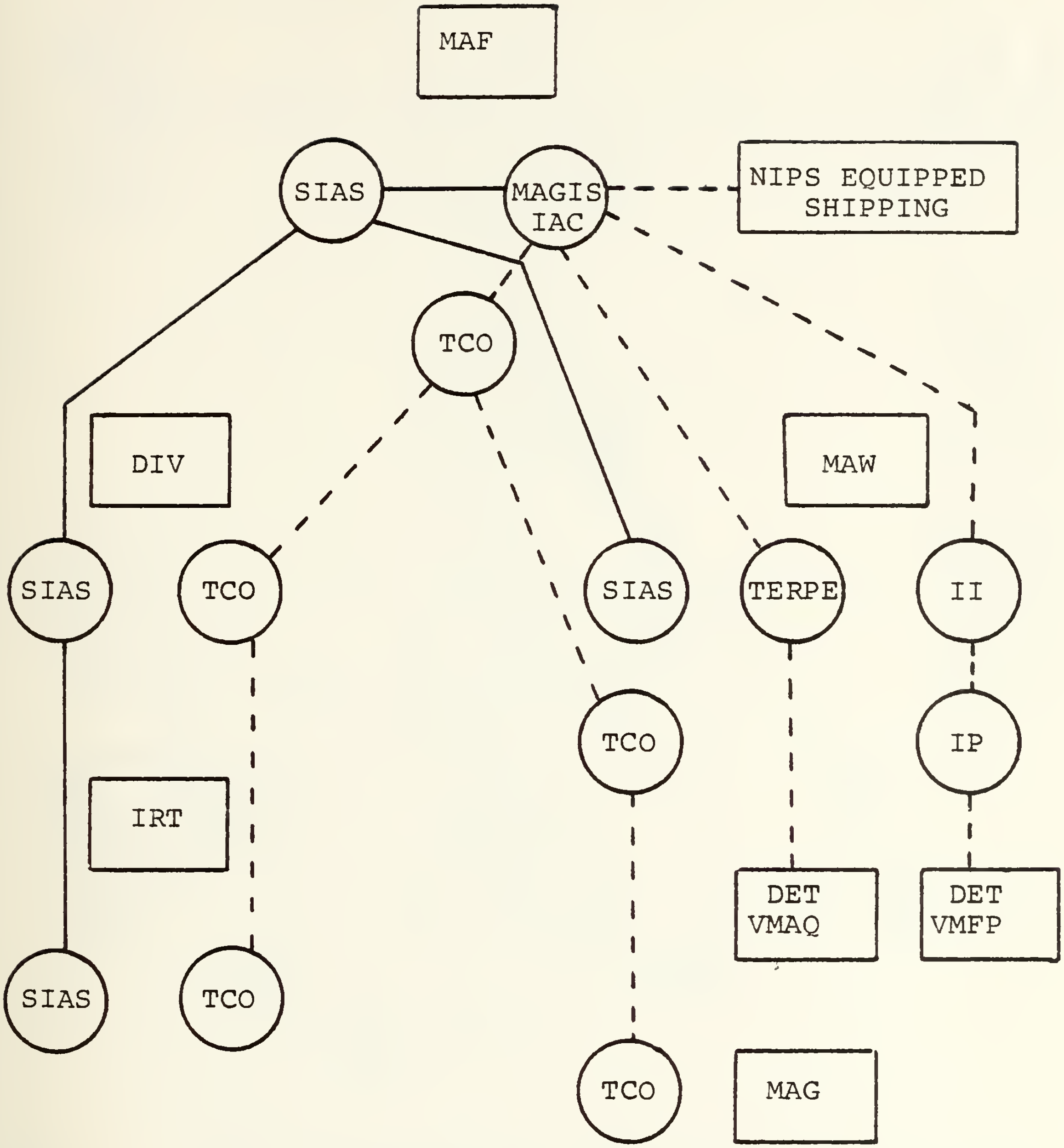


Figure (4) TCO Logical Interfaces And Information Flow



NOTE: Only initial TAOC-85 to MIFASS and TAOC-85 to TCO interfaces are shown. See Figures (3) and (4) for MIFASS and TCO logical interfaces and information flow.

Figure (5) TAOC-85 logical interfaces and information flow

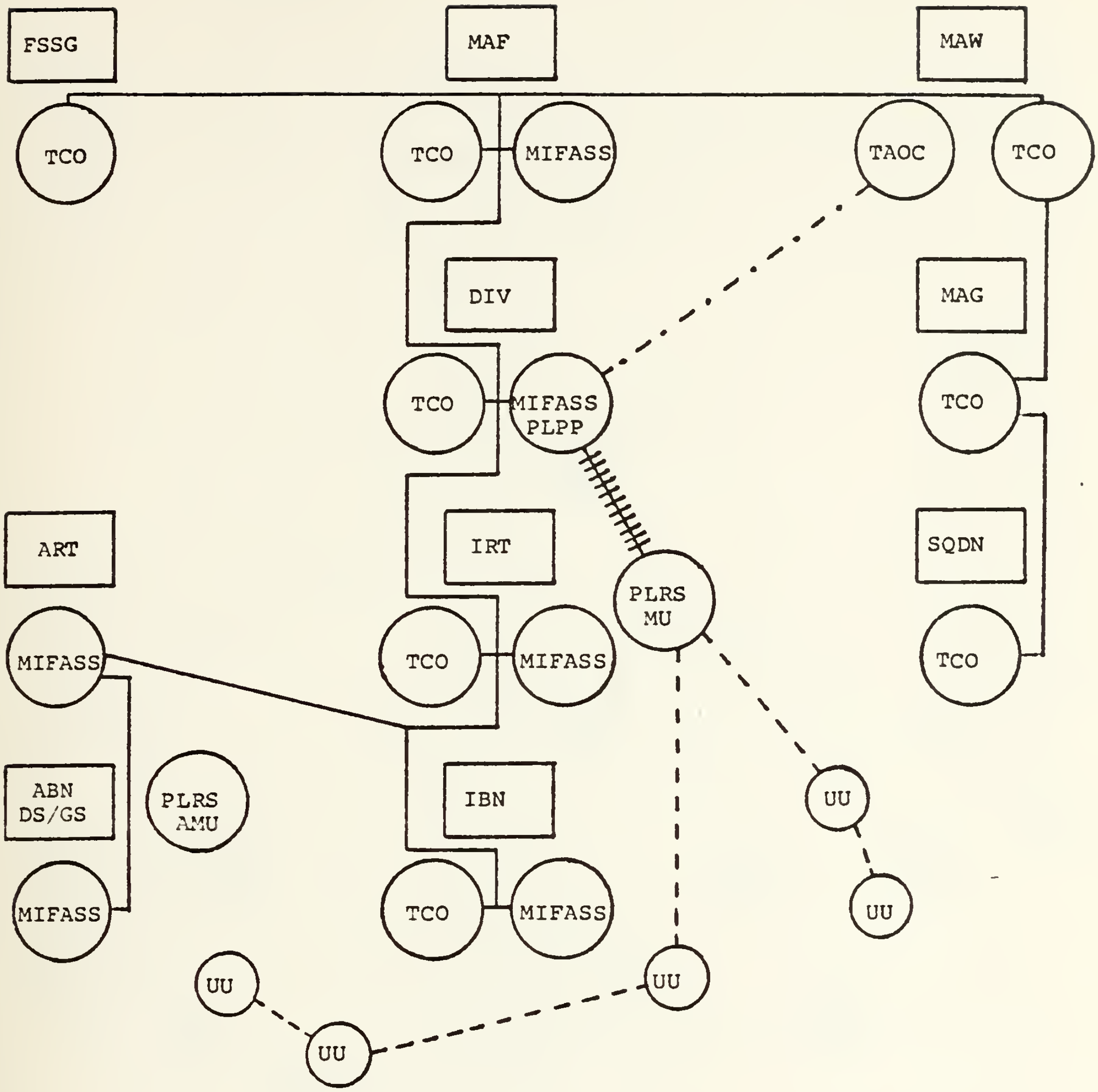


LEGEND

Logical MAGIS Links - - - -
Logical SIAS Links ________

NOTE: Only representative TCO interfaces are shown.

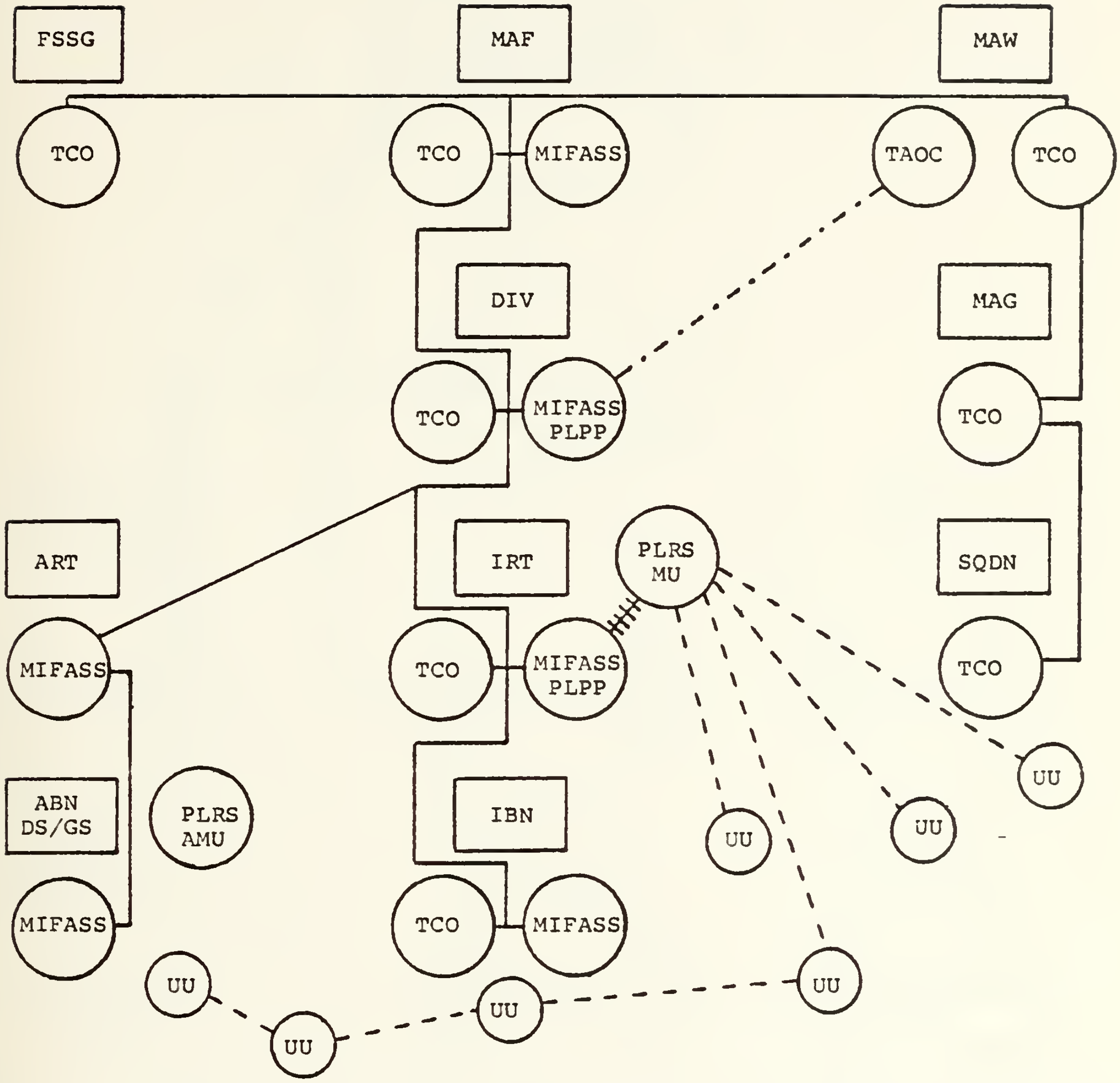
Figure (6) MAGIS logical interfaces and information flow



NOTES: 1. ONLY representative TCO/MIFASS links are shown.
2. ONLY representative UUs are shown.

------ PLRS UU-MU Link
┼┼┼┼┼┼ PLRS MU-MIFASS PLPP Link
-.-.-. TAOC-85 - MIFASS PLPP Link
——— Distribution of PLI VIA MIFASS/TCO

Figure (7) PLRS Functional Interfaces And Information Flow With Centralized PLI Processing



NOTES: 1. ONLY Representative MIFASS and TCO links are shown.
2. ONLY Representative UUs are shown.

------ PLRS UU-MU Link
┼┼┼┼┼ PLRS MU-MIFASS PLPP Link
—.—.—. TAOC-85-MIFASS PLPP Link
——— Distribution of PLI via MIFASS/TCO

Figure (8) PLRS Functional Interfaces And Information Flow With Decentralized PLI Processing

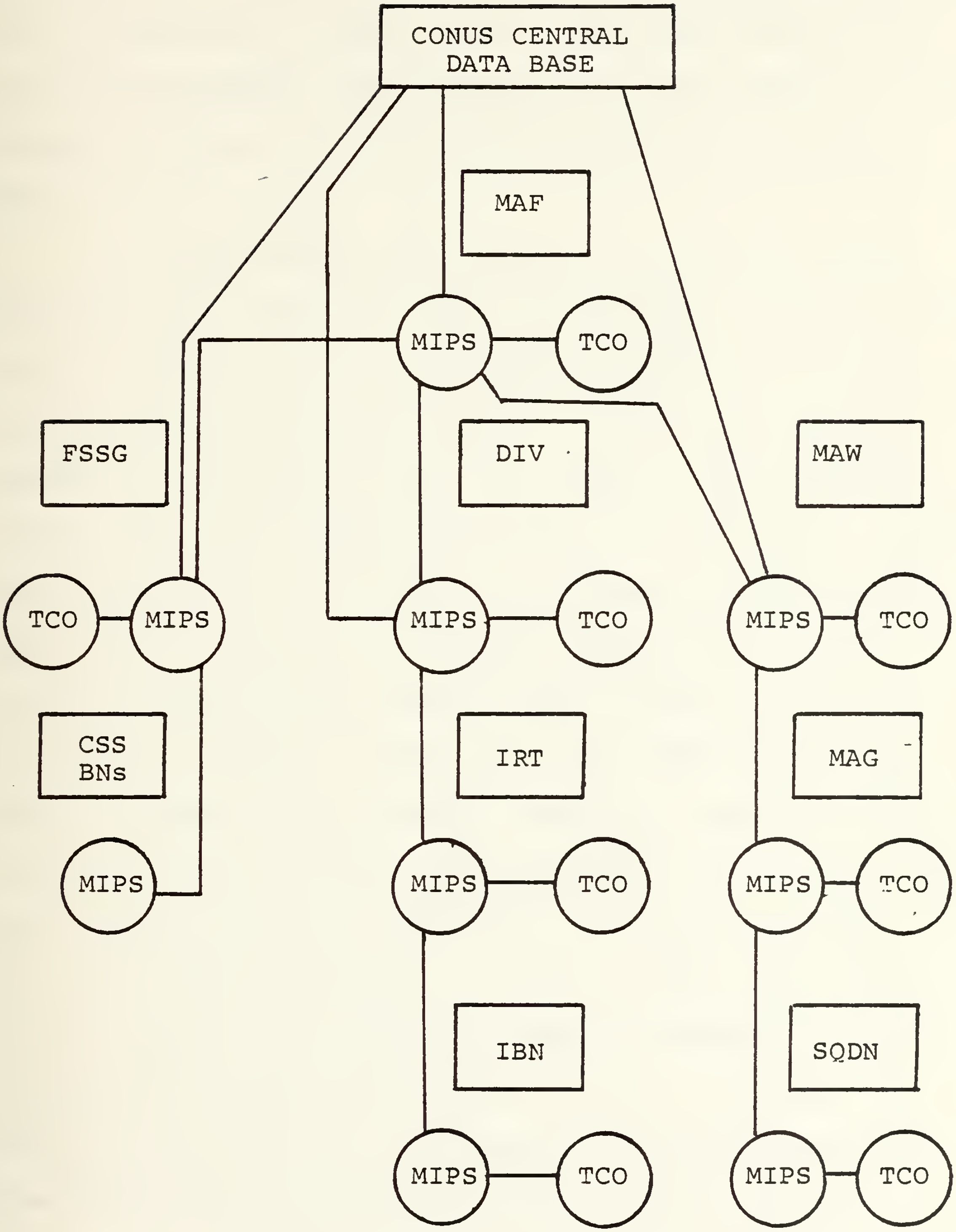


Figure (9). MIPS functional interfaces and information flow.

become available. It is this feature where the issue of centralization of the command function and the control function is embedded. Virtual circuit capability results from the interoperability requirements mandated by MTACCS and the automatic switched communications networks envisioned by LFICS.

In the opinion of the author, the virtual circuit capability will drive the future command and control system toward centralization. As discussed in Chapter II, the current command and control system relies on the chain of command for information flow. For example, the MAF headquarters does not interface directly with a regiment. Rather, the division acts as a buffer and screens all information. Under MTACCS however, all commands having access to the switched communications network have virtual circuits with any tactical computer system within the MAGTF command and control system. This increased capability implies centralization of both the command function and the control function when data not previously available on a real-time basis is fed to the higher echelons of command. Thus, the virtual circuit may very well usurp the chain of command and drive the automated command and control systems to a degree of centralization that will be essentially determined by the communications network providing the physical links.

The purpose here is not to debate the centralization issue, but rather to explore a possible command and control structural change and relate that change relative to the management and control of the communications system.

B. MARINE INTEGRATED FIRE AND AIR SUPPORT SYSTEM (MIFASS)

1. MIFASS Agencies

The MIFASS concept, as prescribed in the MIFASS acquisition plan and system description document, provides for the establishment of fire and air support centers (FASCs) to integrate, direct, and coordinate supporting arms. At each echelon of command, the FASC will replace the current manual fire support coordination center (FSCC) and will assume selected functions of the supporting artillery fire direction center (FDC). FASCs at each echelon may also perform selected air control functions. The MAGTF headquarters will have a fire and air support section (FASS), designed and equipped to monitor all aspects of the supporting arms situation. Figure (10) depicts MIFASS agencies and their major responsibilities. Relating the agences of Figure (10) to the command and control functions discussed in Chapter II, it appears that the control function takes on a greater importance at all levels of command.

2. MIFASS Message Flow

The sequence for processing a request for indirect fire support is shown in Figures (11) and (12). Typically,

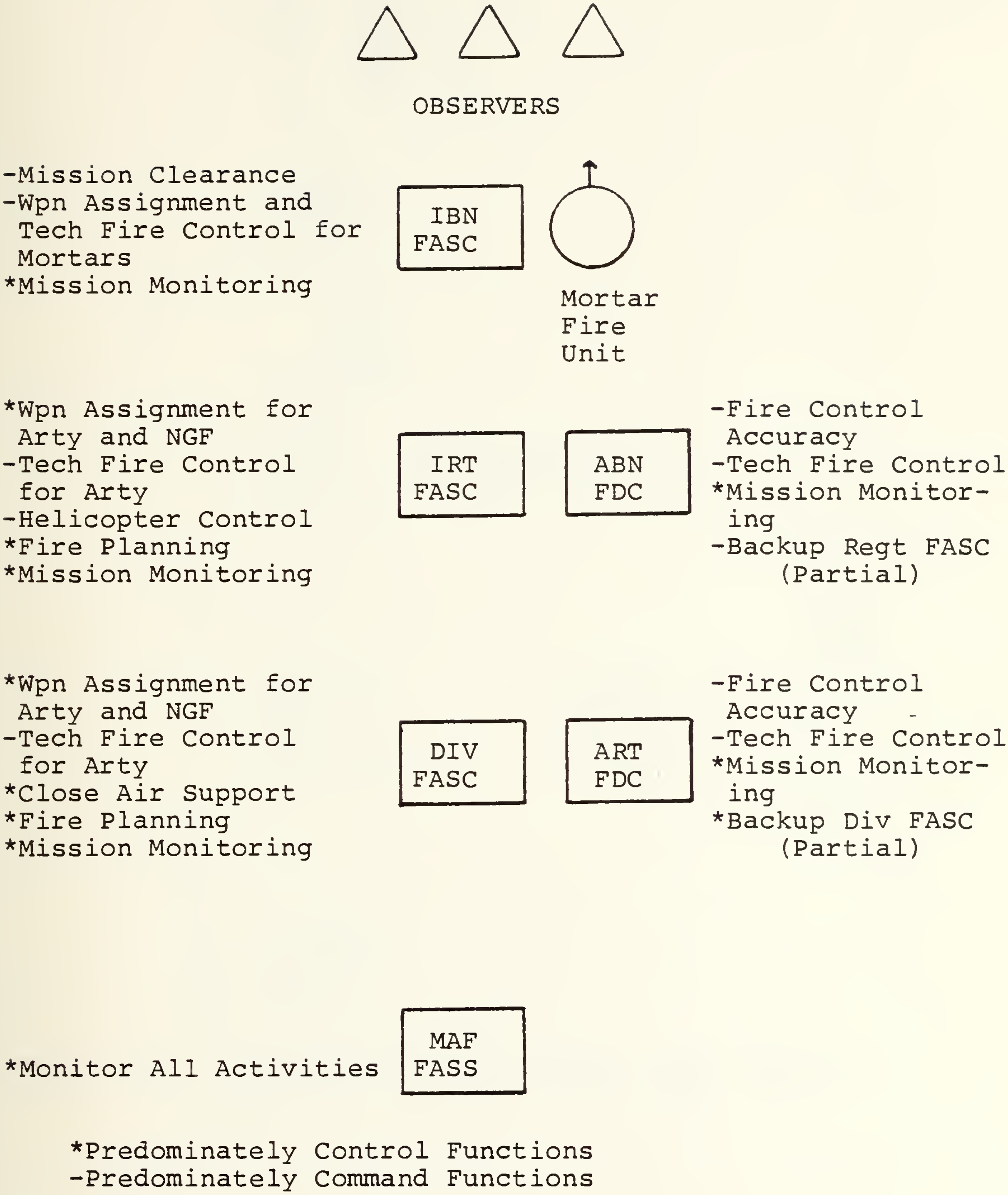


Figure (10). MIFASS agencies and their responsibilities.

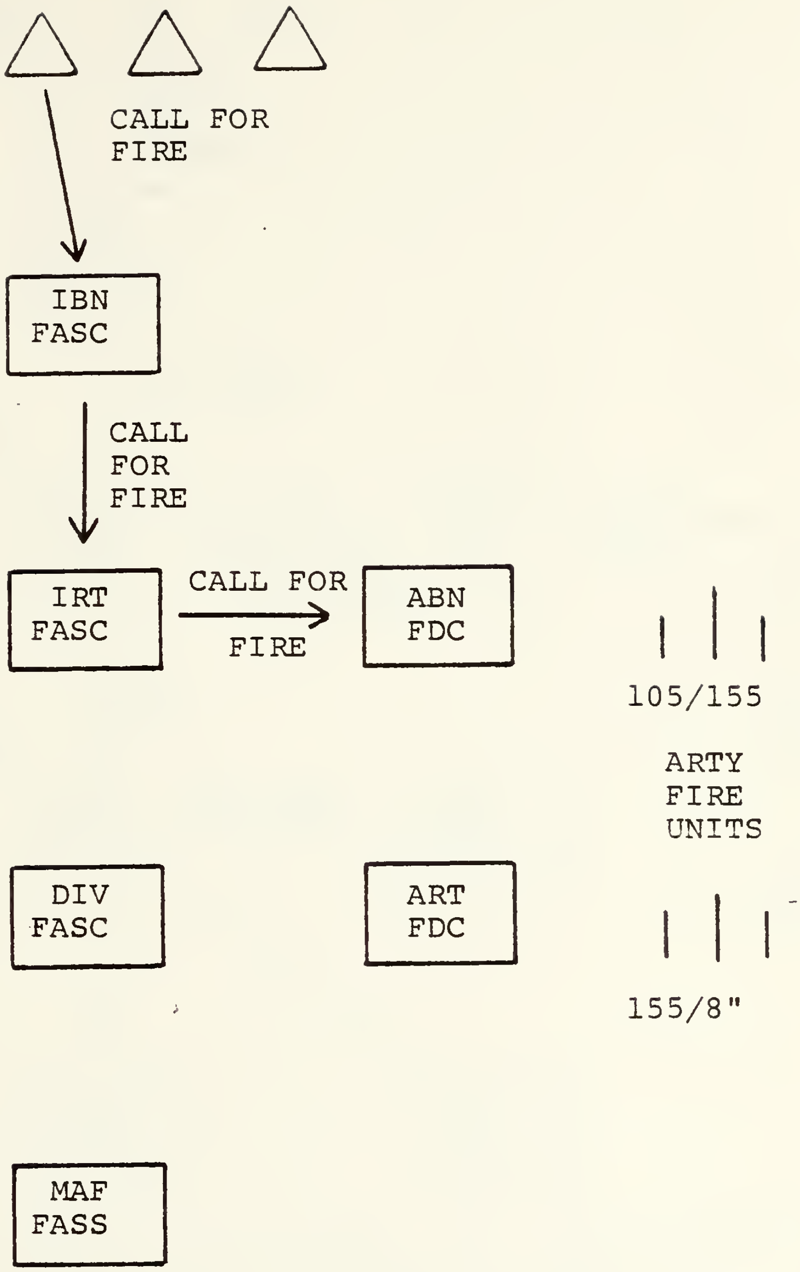


Figure (11). Processing of an indirect fire support mission, inital call for fire.

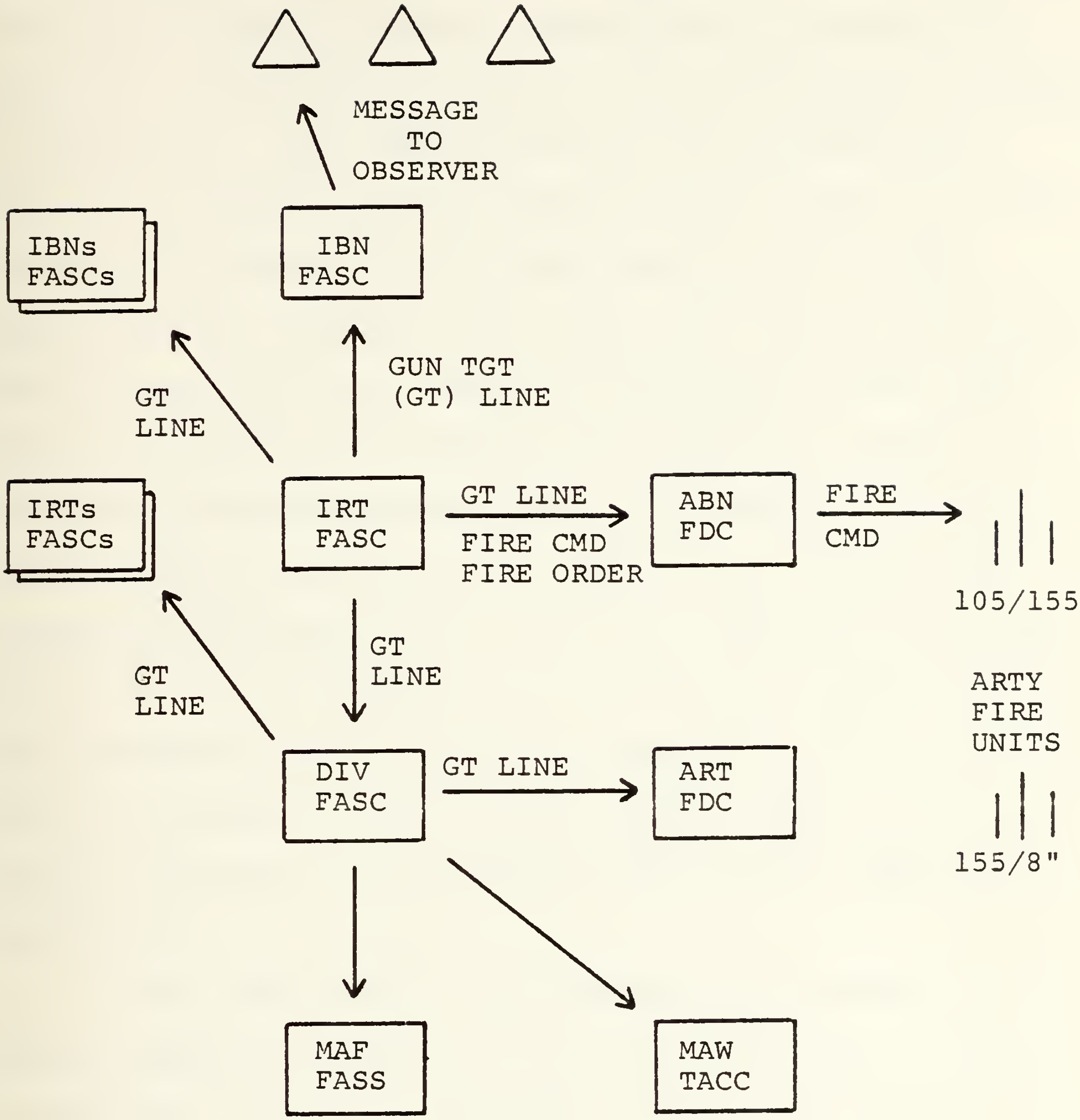


Figure (12) Processing of an indirect fire support mission, distribution of fire mission information.

an observer acquires a target and digitally transmits a call for fire through his digital communications terminal (DCT), depicted in Figure (11). (Functioning of the DCT is explained in Appendix B.) The communications system automatically routes the message to the appropriate FASC in whose area the support will be employed and simultaneously to the FASC controlling the supporting arm requested. The area-coordinating FASC will clear the request by verifying friendly unit safety and ensuring conformance with any other limiting measures. The implementing orders, including fire commands and gun target lines, are then automatically computed and transmitted digitally to the FDC of the appropriate delivery agency and to other centers, as illustrated in Figure (12). The controlling FASC continues to monitor the mission and, by means of automatic digital status messages, keeps the FASCs and FDCs informed of the progress and eventual completion of the mission.

With this in mind, the augument can be made that the primary purpose of MTACCS is to provide the control function. In addition, it is the information flow between agencies that drives the control function and, as such, will require special communications requirements and considerations. Communications will be examined in Chapter IV of this thesis.

C. TACTICAL COMBAT OPERATIONS SYSTEM (TCO)

TCO is a tactical data system designed to provide automated assistance and real-time information to G-3/S-3 and S-2 operations center personnel at all levels of command in the MAGTF. The general purpose of TCO is to enhance the capability of the commander and his operational staff to conduct combat operations and advance planning by disseminating selected information vital at each command echelon for effective planning and execution of combat operations.

TCO, as a command and control system, provides a means for obtaining timely and accurate information to the user in a more manageable form. This will be accomplished by employing digital data communications, automated data manipulation, and display of selected information. For example, the PLRS data will be transmitted to TCO at a predetermined refresh rate through TCO's interface with the MIFASS Position Location Post Processor. This information will be automatically displayed on the Dynamic Situation Display of ground unit TCO centers and the large screen display of the aviation TCO center located at the Tactical Air Command Center (TACC).

D. TACTICAL AIR OPERATIONS CENTRAL-1985 (TAOC-85)

TAOC-85 is envisioned as a tactical data system devoted to operational and control of Marine aviation. The system is intended to provide airspace and air asset management, and control of all aircraft and air defense weapons systems.

Overall command and coordination functions are envisioned to be accomplished at the Air Wing command level through the TCO (TACC) system, while actual control of aircraft and air defense means will be conducted by TAOC-85.

TAOC-85, as a command and control system, is a modularized basic grouping of equipment, including both hardware and software, which can be configured as a automated Tactical Air Operations Center (TAOC). Modularization of the system is intended to provide versatility for the Tactical Air Commander to rapidly deploy the air control capability required by friendly and enemy air situations. The independent operational features associated with each operations module assures a graceful rather than catestrophic degradation in case of system failure.

Each operations module, with associated communications and sensor equipment has the inherent capability to perform the following functions: data exchange and processing, real-time display, automated target tracking, and automated air defense/air control.

E. MARINE AIR-GROUND INTELLIGENCE SYSTEM (MAGIS)

1. General

MAGIS is an integrated tactical data system intended to provide timely and accurate intelligence on which to base tactical decisions. Its primary purpose is to substantially increase the ability of the MAGTF to produce targeting

information and to correlate surveillance data and intelligence. Chase [Ref. 8] points out that "The historic imbalance between intelligence data collection and processing will be eliminated by the introduction of MAGIS into the intelligence processing."

MAGIS is a subsystem of the Naval Intelligence Processing System (NIPS), and will consist of the following segments: Image Processing, Imagery Interpretation, Tactical Electronic Reconnaissance Processing and Evaluation, and the Intelligence Analysis Center. Closely aligned with, but not a segment of MAGIS, is the Integrated Communications Collection/Signal Intelligence Analysis System.

2. <u>Image Processing (IP) Segment</u>

The IP segment provides the capability to process multisensor imagery acquired by the Marine tactical reconnaissance squadron (VMFP) and for duplicating, printing,-and enlarging photographic materials required for intelligence and operational use. Output of the IP segment is primarily to the Imagery Interpretation (II) Segment.

3. <u>Image Interpretation (II) Segment</u>

The II segment contains the automated equipment needed for rapid and accurate interpretation of imagery and the fast reporting of the information gained through formatted interpretation reports, plots, and other products. System output will be to the Intelligence Analysis Center located at the MAGTF and senior ground command headquarters.

4. <u>Tactical Electronic Reconnaissance Processing And Evaluation (TERPE) Segment</u>

The TERPE segment performs processing, evaluation, and reporting of electronic reconnaissance information collected by EA-6 A/B aircraft systems. TERPE systems are assigned to the Marine tactical electronic warfare squadron (VMAQ). Output from the TERPE segment is provided to VMAQ for mission planning and to the G-2 section of the MAGTF headquarters.

5. <u>Intelligence Analysis Center (IAC) Segment</u>

The IAC segment is the heart of MAGIS. The IAC may be deployed with either the MAF or division headquarters or with both depending upon the availability of assets and the desires of the MAGTF commander. Information from other MAGIS segments and agencies will be passed to the IAC for processing into all-source intelligence. Intelligence generated within MAGIS will be distributed to echelons below the IAC through TCO and reports from subordinate units will be funneled up through TCO to the IAC as appropriate. Information transfer will be accomplished through the automatic message switched network provided by LFICS.

6. <u>Signals Intelligence Analysis System (SIAS)</u>

As previously mentioned, SIAS is closely related to, but is not a part of MAGIS. SIAS is a semiautomated system designed to provide the supported commander the MAGIS with timely signals intelligence (SIGINT) and electronic warfare

(EW) support. SIAS output is to the G-2/S-2 section of the supported command and to the SIAS at the next higher headquarters.

F. POSITION LOCATION REPORTING SYSTEM (PLRS)

The PLRS is basically a system for obtaining and providing position location information (PLI) for tactical ground and aviation units. Electronic equipment, known as user units (UU) provide or receive information from a master unit (MU) or alternate master unit (AMU). The MU transmits this information to a Post Location Position Processor (PLPP) which is a direct interface with MIFASS. Information from the MIFASS/PLPP interface is intended to significantly enhance PLI transfer between MIFASS, TCO, and TAOC-85 and provide real-time information on locations of friendly units for fire support coordination and control purposes.

Processing of PLI will either be centralized at the division FASC or decentralized at the regimental FASCs. The method of PLI processing will be at the direction of the MAGTF commander. Information transfer flow with centralized PLI is depicted in Figure (7). Decentralized processing is depicted in Figure (8). Information transfer between the master unit and the MIFASS/PLPP interface unit will be through a dedicated physical data link in both centralized and decentralized processing.

G. MARINE INTEGRATED PERSONNEL SYSTEM (MIPS)

MIPS is a tactical data system designated to provide improved manpower management through selective automation. MIPS is considered a tactical subset of the real-time finance and manpower management information system, the future Marine Corps-wide total manpower system (REAL FAMMIS). As such, MIPS can be considered as an input/output system encompassing essential personnel management, finance, accounting and other G-1/S-1 functions of REAL FAMMISS that are requisite for effective MAGTF operations.

H. THE LANDING FORCE INTEGRATED COMMUNICATIONS SYSTEM (LFICS)

1. General

LFICS is a system of personnel, equipment, and procedures that is tasked with providing communications support to a deployed MAGTF. It encompasses all communications assets required to support the entire landing force, including those required to provide information transfer support for the MTACCS tactical data systems. For the purposes of this thesis, LFICS discussion will be limited to system functions designated to furnish the data communications and interconnectivity required for information transfer among the MTACCS tactical data systems.

2. LFICS/MTACCS Interfacing

MTACCS tactical data systems can be categorized, for communications purposes, as real-time and non-real-time. TCO,

MIFASS, MAGIS, TAOC-85, and PLRS PLI are real-time systems that are envisioned to be served by physical links established through a message switched network. MIPS is a non-real-time system that will utilize physical links established through a circuit switched network.

The communications system supporting MTACCS can be differentiated into four broad functional areas for overall system description: (1) transmission system employment and equipment, (2) switching system employment and equipment, (3) communications terminal equipment, and (4) network management and control. The LFICS architecture specifies equipment designated for use within the automatic switched networks. Appendix B of this thesis provides a description of those equipments. Chapter IV of this thesis provides analysis for the functional employment of transmission and switching systems and develops a theoretical model for optimizing network management, control, and overall performance of automatic circuit and message switched networks.

IV. MANAGEMENT OF AUTOMATIC SWITCHED NETWORKS

A. GENERAL

To exercise command, and to control an array of automated battlefield systems envisioned under the MTACCS concept, will require a network design that provides highly reliable information transfer. To lose information may render an automated system completely unusable. In systems such as MIFASS, injected errors could cause misdirected and misguided weapons delivery. Likewise, errors in a transmission from an originator not only will affect the data base of the destination addressee, but also will impact exponentially on all data bases because of the shared data base concept and query/response capability envisioned under the MTACCS. In essence, Marine Corps communications managers will be tasked with planning, installing, operating, and maintaining what amounts to a tactical "mini-Bell System". Unfortunately, the luxury afforded AT&T of having a static, stable and immobile system will not be provided to the Marine communications manager. Rather, the system he installs will be subjected to frequent dismantling for displacement purposes, high user demand, and possible loss of key nodes through equipment failure or unfriendly actions.

FMFM 10-1, the Marine Corps' manual for communications [Ref. 9], defines an effective communications system as having

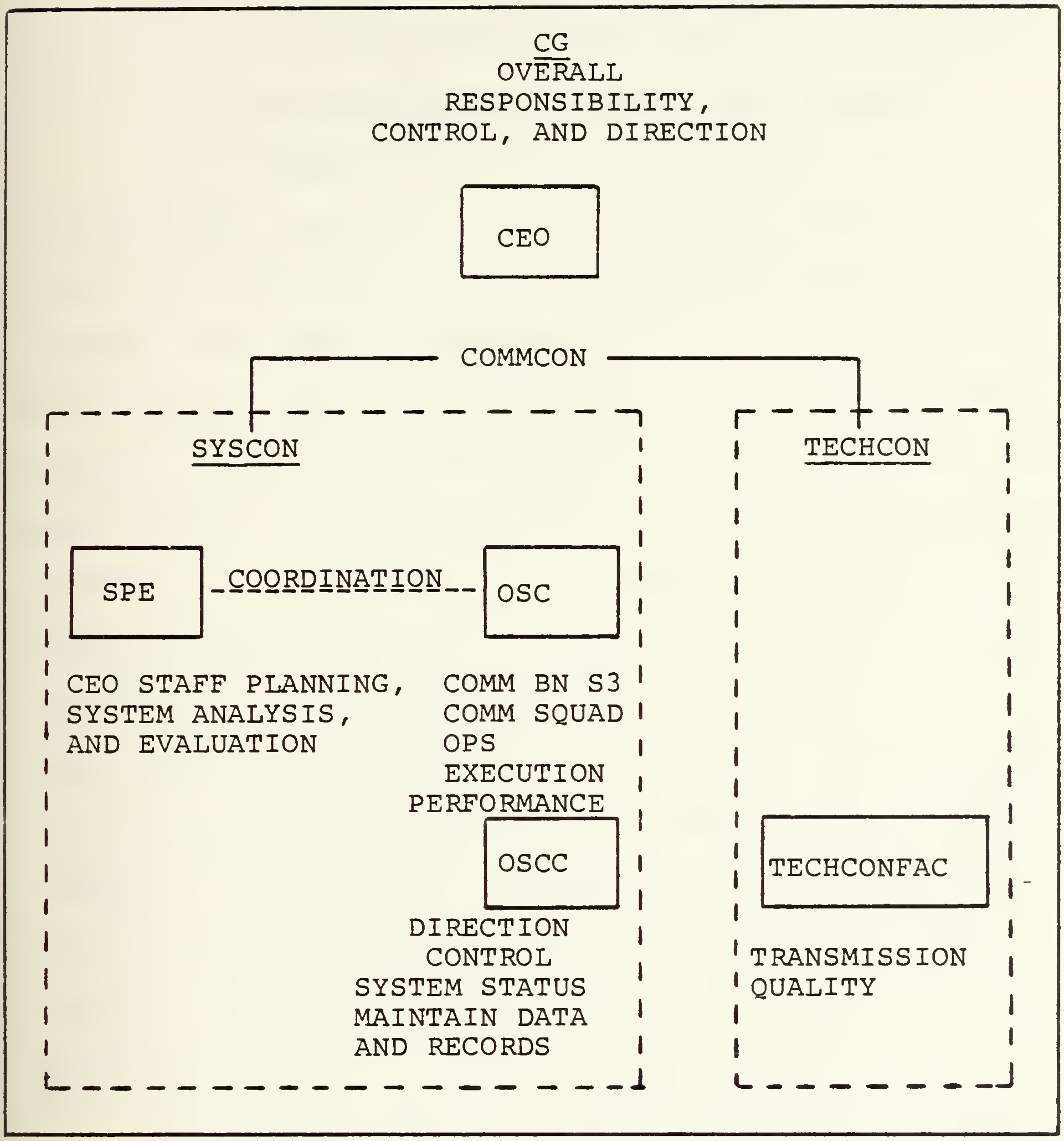
the fundamental requirements of reliability, security, speed, and flexibility. These standards have provided and will continue to provide, sound objectives for communications managers. Nevertheless, the demands of MTACCS portend major challenges in meeting those requirements on future battlefields. Changes in doctrinal communications management, organizational structure of communications units, and employment of multichannel radio communications may be required.

B. THE STRUCTURE OF COMMUNICATIONS MANAGEMENT

1. Communications Control

FMFM 10-1 defines communications control as the concept of overall control of telecommunications resources to provide positive responsiveness of telecommunications [Ref. 10]. It includes such requirements as organizing, directing, coordinating, planning, and evaluating communications resources to accomplish assigned missions and tasks. The extent that the management practice of communications control is successful largely determines the success in supporting the commander's command and control requirements.

Doctrine divides communications control in the Marine Corps into two areas: systems control and technical control. Systems control is subdivided into the two functional areas of system planning and engineering (SPE) and operational system control (OSC). Figure (13), extracted from FMFM 10-1,



NOTE: In organizations below the division/wing level where extensive test equipment is not available, the concept of COMMCON will consist primarily of a system control with limited technical control under the direction of the communications officer.

Figure (13) Communications Control Organization and Functional Interfaces.

depicts the communications control function organizational chart and illustrates the functions of each control agency.

2. Current Communication Control Functioning

The communication management structure currently in use throughout the Marine Corps can be best described as centralized planning with decentralized management and execution. Each unit of Regimental size or larger has its own multichannel radio communications resources and personnel to install, operate, and maintain portions of the overall automated trunking and switching system. Directions concerning operation and management of the system follow the chain of command through each unit's communications control agency. Command relationships between these agencies are informal since FMFM 10-1 dictates that the commander is responsible for the adequacy and proper use of communications within his command. Overall system management, and subsequent reliability is then determined by the state of each individual command's equipment readiness and training, and the network management demands of the next higher headquarters.

Likewise, current doctrine states that communications between a senior and a subordinate command is the responsibility of the senior. For example, multichannel radio links between a MAF headquarters and a division headquarters are the responsibility of the MAF to install, operate, and maintain. Links between division and a regiment are the responsibility of the division. Overlaying this doctrine on a

MAGTF tactical automatic trunking and switching system, where system management and operation is crucial for overall reliability and where ultimate responsibility for system operation rests with the MAGTF headquarters, may cause problems to arise through differences in unit operating procedures, maintenance standards, training standards, and command requirements. This doctrine should work well in the case of the MAF to division link, but may not work well at lower levels where priorities are local command perogatives. As a consequence, overall network integrity and reliability may suffer.

C. THE REQUIREMENT FOR CENTRALIZED CONTROL

1. Factors For Centralization

The bulk of MTACCS communications will be digital data message traffic, both operator and computer generated, through a message switched network [Ref. 11]. While many of the messages will be generated through operator action, the majority will be generated automatically by computers in response to other stimuli. Additional circuit switched voice communications will be required to provide timely information exchange between individuals in the exercise of fire and air support functions or other control requirements dictated by the tactical situation. Communications through the circuit switched system will be used with a standard abbreviated dialing scheme and established call precedence. Requirements

for circuit switched voice communications, however, will diminish as a result of greater reliance on the message switched network for information transfer. Analysis conducted by the Marine Corps Tactical Systems Support Activity (MCTSSA) on multichannel requirements for support of MTACCS forecasts a 20 percent decrease in voice communications due to message switching [Ref. 12].

Tables (1) and (2) provide insight concerning the traffic load density envisioned for transmission over the message and circuit switched networks [Ref. 13]. The reader should be aware that nodal to nodal information flow is not accurately represented since the tables are structured in parallel with the chain of command. For example, data flow from the Marine Air Wing (MAW) to Division (DIV) and below is included in the MAF to Division traffic density. The traffic densities, however, are important only to the extent that they illustrate the dependence of MTACCS on the automatic switched networks for transfer of command and control functions and information.

Obviously, the dependence of the MTACCS tactical data systems on the automatic switched networks requires unique and vigorous management practices. Allen [Ref. 14], explained the Army's philosophy:

> "When automatic computer-driven switches are connected to form a switched network, management and control of these switches becomes very critical."

	MAF	DIV	IRT	ART	MAW	MAG	FSSG	CSS BN	JTF CMDR
MAF		45.1			28.9		45.1		5.1
DIV	2.4		10.52	3.36					1.8
IRT		.55							
ART		.189							
MAW	2.5					.99			2.55
MAG					.99				-
FSSG	2.5								31.32
CSS BN									
JTF CMDR	79.9	32.6			7.2		18		

TABLE (1) TOTAL 1988 MESSAGE SWITCH DATA TRAFFIC (PARTIAL MAF ORGANIZATIONAL STRUCTURE) KILOBITS PER SECOND (Kbps)

	MAF	DIV	INF REGT	ART REGT	MAW	MAG	FSSG	FSSG BN	HIGHER HQ
MAF		102			49		41		30
DIV	70		32	59	31				14
INF REGT		45							
ART REGT		78							
MAW	28	31				116			36
MAG					111				
FSSG	42							6	23
FSSG BN							34		
HIGHER HQ	85	69			42		14		

TABLE (2) TOTAL 1988 CIRCUIT SWITCH TRAFFIC
(PARTIAL MAF ORGANIZATIONAL STRUCTURE)
(CALL MINUTES/BUSY HOUR)

This need was recognized by the Army Signal School in 1975 when the concept of a tactical automatic switch control office was being examined and validated.

> "A valid requirement exists for the establishment of a tactical automatic switch control office (TASCO) for managing the overall operation of the tactical automatic switched (TAS) network. The TASCO will perform, on a centralized basis, certain planning, engineering, and operational control functions which impact on overall system efficiency. The objective of the TASCO is to ensure the TAS network is fully responsive to the needs of tactical commanders. This concept is based upon several considerations. First, TAS routing is accomplished automatically and the operator is removed from the normal call processing chain. Second, each link supports more than the routing needs of the nodes it interconnects. Finally, the complexity of engineering a TAS network, caused by software (logic) features and constraints, makes centralized management a necessity. Without benefits of the "big picture", unilateral actions initiated by local controllers would have an adverse impact on overall system performance."[Ref. 16]

FM 24-26 (Tactical Automatic Switching) was subsequencly published in April, 1977. It establishes guidelines for planning, operating, and managing an automatic switched network.

Tactical automatic switched networks are not easily implemented. For example, in 1977 the Marine Corps fielded an automatic switched network utilizing AN/TTC-38 and SB-3614 circuit switches with the AN/TSQ-84 technical control facility. A myriad of problems evolved with this system. Utilized properly, however, these problems can serve as excellent lessons learned for fielding and operation of the MTACCS/LFICS switching systems. A command letter from 8th Communications Battalion, quoted in part below, addresses a few of these problems and vividly portrays the requirement for centralized management and control:

"Both in the actual communications support of the Exercise and in scenario planning, it was readily apparent that the Marine Corps has a serious deficiency of personnel with the hard technical skills vital to the installation, operation and maintenance of anything but the most rudimentary of systems. Had it not been for the assistance of civilian technical representatives..., and the invaluable assistance of U.S. Army CERCOM (Communication-Electronic Readiness Command) the entire exercise would have collapsed for want of technical expertise...To expect that the Marine Corps will be able to install and operate a communications network sophisticated enough to satisfy the real needs of a MAGTF...committed to an operation is flirting with disaster. Marine technicians and operators could not install the sophisticated system given their present state of maintenance preparedness and operator proficiency in less than a 10-day interval (those ten days begin when all equipment is ashore and all maintenance facilities operational)...

Recommendations: First, restructure priorities. Keep hard skilled personnel in hard skill billets. If this means reducing end strength then so be it. It is far better to have a small cadre of highly skilled, technically proficient Marines than a vast reservoir of semi-skilled, technically inept personnel no matter how dedicated they are. Secondly, investigate the feasibility of implementing a CERCOM analogous agency within the Marine Corps. Rather than foster dependence on civilians this concept provides for highly skilled teachers in a field environment..." [Ref. 17]

While the problems that 8th Communications Battalion experienced on Exercise Positive Leap 80 are but a sample of one, they nevertheless are reflective of the author's experiences and observations with the same automatic circuit switched system.

Centralization on a scale required for maximization of network performance is not without problems however. It conflicts with doctrine, command relationships, and worst of all, tradition. Commanders can be expected to vigorously defend their "assets" and, under pre-MTACCS/LFICS, their

doctrinal perogatives in carrying out their command functions. FMFM 10-1 provides interpretations on the roles of communications in the command process:

> "The primary purpose of communications is to serve command. In this role, communications is the instrument by which a commander makes his will known and, as such, is the "voice of command". Communications permit the commander to exert personal influence in the exercise of command and control of assigned forces, supporting fires, and logistics support over larger areas than would otherwise be possible. Any transmission speaks only for and with the authority of the commander who originated the transmission.
>
> The secondary purpose of communications is to facilitate the transfer of information between individuals and groups of individuals which is necessary to the exercise of command." [Ref. 18]

Applying this doctrine to a system with automatic information transfer among tactical data systems; up, down, and laterally through the chain of command, via a message switched network, proves challenging. This doctrine quite obviously is structured around the command function where voice communications from commander to commander is utilized for information transfer. It does not, however, support the evolution and functioning of tactical data systems which will automate information transfer now accomplished by voice. The figures of Table (1) indicate the extent of automation and data transfer. Indeed, at the higher echelons where the command function is dominant (see Figure (2)) and where MTACCS will have the greatest impact, the argument can be made that information exchange between tactical data systems (the control function) replaces the command function as the primary

purpose of communications and, as such, will drive the functioning of the communications system.

In an integrated MTACCS/LFICS network, all commanders will be equally reliant on optimal network performance for information transfer. This mutual dependence will require a surrender of local control to centralized control since the portion of the network serving unit commanders will serve more than local communications needlines and command requirements when the alternate routing capabilities inherent in automatic switching are considered.

Logically then, centralized planning, control, execution, and management appears as the optimal alternative in providing the type and grade of service demanded by MTACCS.

2. The Degree Of Centralization

a. Centralization Of Personnel And Equipment

The most probable means of employment of Marine Forces will be in the form of a MAGTF. MAGTFs are characterized by operational concepts, organizational structure, and equipment and systems which are mission suited [Ref. 19]. In essence then, each unit within the MAGTF is task organized to meet the mission requirements. Based on that assumption, the logical choice for centralization of personnel and equipment required to install the "mini-Bell System" alluded to earlier would be at the communications battalions which doctrinally and traditionally support the MAGTF headquarters [Ref. 20].

Centralization of personnel and the circuit/message switches along with the associated transmission systems and external power sources provides readily apparent benefits. First of all, communications personnel will receive the training necessary and will garner the experience and knowledge required for operating a sophisticated system. Additionally, the cohesiveness in working together will increase the speed of installation and enhance overall system effectiveness. Secondly, centralization will allow for greater flexibility for the system manager in ensuring a robust and reliable switched network since he will know the capabilities and limitations of personnel and the maintenance status of all equipment throughout the network. Lastly, centralization will ensure standardized maintenance procedures and provide the most cost-effective utilization of highly-trained maintenance personnel. Concurrently, the side-benefit of increased technical expertise will be attained, since communications battalions are normally authorized up to fourth echelon maintenance for communication-electronics equipment.

Naturally, centralization of this scale will not come without costs. Force reductions in the tables of organization and equipment throughout other communications units to restructure the communications battalions will be an immediate cost. Coupled with the force reductions is a hidden cost that requires addressing; this is the phenomenon known as "quality creep". Inherent in new technology data communications

will be an increasing demand for hard-skill personnel such as data communications technicians, computer technicians, and operational data communication operators. The "creep" occurs when lower skill occupational specialties are converted to higher skill. In such cases, tradeoffs, realignments, and compensatory reductions have to be made in the overall Marine Corps structure in order not to exceed Congressionally mandated end strength.

b. Planning

The automatic circuit/message switched networks will transcend communications nodes and units with a degree of transparency never before seen. The interconnectivity among MTACCS automated systems and their subsequent dependence on switched networks requires a centralized source of planning to integrate all variables and system nuances.

Centralized planning for switched networks will not depart radically from current practices. The MAGTF communications-electronics officer, in conjunction with unit communications officers, determine overall network needs, requirements, and operation. This planning is based on mission objectives requirements of unit commanders, and requirements of the switched networks.

c. Execution

Before considering how the execution of installation of switched multichannel systems should be accomplished a brief look at the present nodal interconnectivity is

required. Chapter II described the structure of the current system. Emphasis is placed on the vertical order of senior/subordinate relationships and not on the advantage of possible lateral connectivity for system robustness. This is not to say that lateral connectivities are never used; rather, it merely affirms the notion that the chain of communications follows the chain of command.

The MTACCS concept envisions the primary means of communications between nodes to be the switched, multichannel system of LIFICS` [Ref. 21]. Inherent in the capabilities of both the circuit and message switches is immediate alternate routing upon failure of primary trunk groups [Ref. 22]. Alternate routing will be accomplished through secondary trunk groups to nodes having logical connections with the destination addressee. Therefore, lateral links become crucial for optimal network performance and the structure of the communications system changes from strictly hierarchial to more distributed in nature.

Figure (14) represents a proposed multichannel trunking and switching scheme that allows for system flexibility and survivability in the case of node or link loss. Under this scheme, personnel and equipment from a communications battalion would provide direct support to unit commanders. Network operational control would be retained by the MAGTF commander through his communications-electronics officer for system performance and network management purposes.

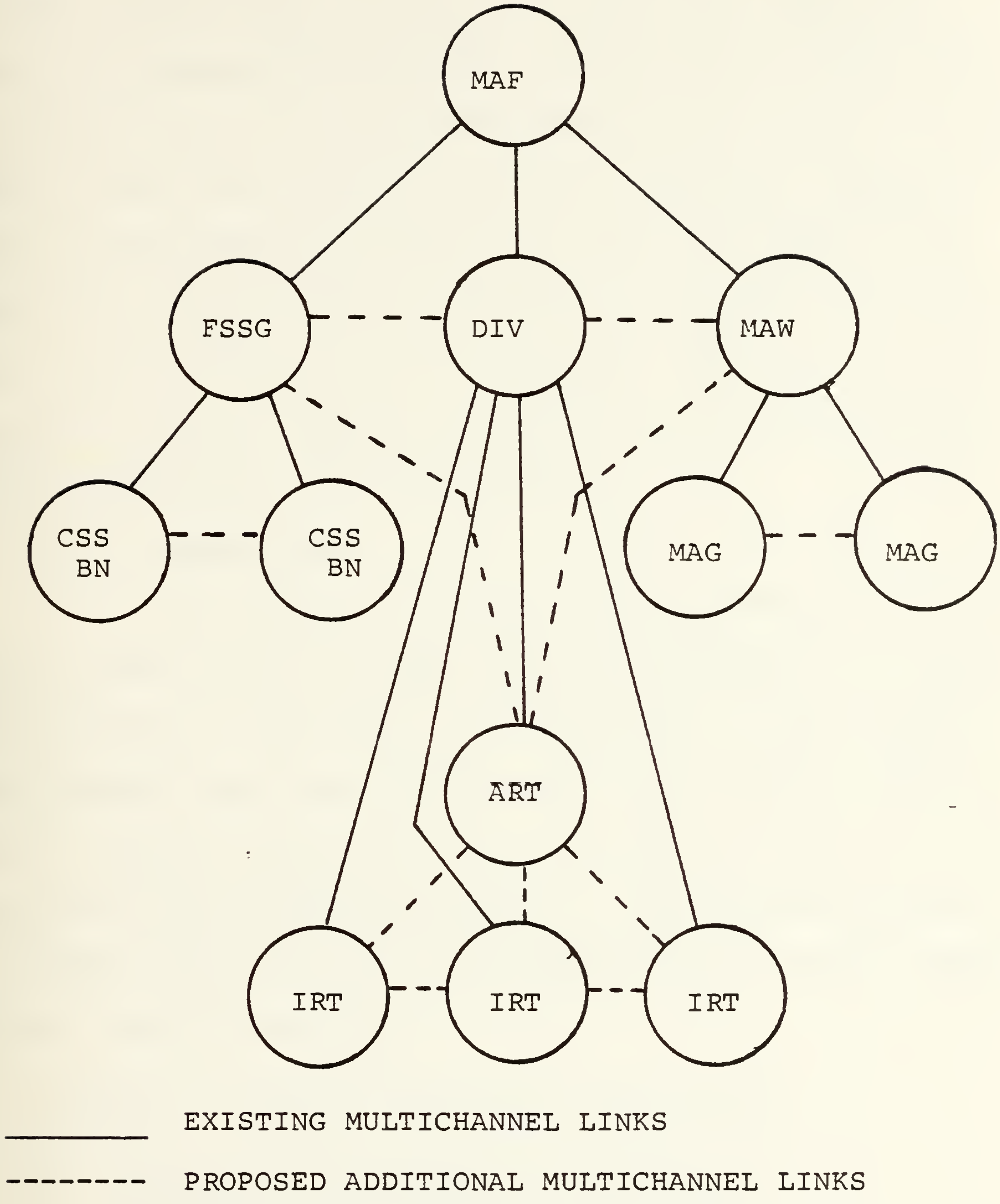


Figure (14) A Model for Future Multichannel Employment.

From a connectivity standpoint, Figure (14) is designed to utilize every existing usable link within the network. While such a system does not itself imply any change in command relationships, it does imply changes in the control process through utilization of a central control agency within the network structure to evaluate communications relationships such as link status and traffic flow patterns to adjust routing of messages according to a user specified set of "optimality" criteria. Thus, the network becomes as richly connected as possible to achieve maximum network flexibility and survivability.

d. Management

The concept of centralized management will have little impact of the current doctrinal approach to communications control. Deviations will occur only in the approach to the automatic switched networks where operational control for overall network functioning at each command echelon will be retained at the MAGTF headquarters. The remaining subsets of the LFICS architecture can be managed under current communications control doctrine.

D. A MODEL FOR NETWORK MANAGEMENT AND CONTROL

1. Equipment And Automation Requirements

Implicit in the development of the model is a dependence on the availability of procurement funds and on digital technology featuring automated reporting and real-time monitoring of network and equipment status.

Automated equipment will provide real-time control and management of the network and will allow traffic to be rerouted around destroyed nodes or jammed links. The equipment designated for the network control agency must display information and provide data-processing aids to help the decision maker (network controller) select the most appropriate modifications to the network in the face of enemy inflicted damage or jamming [Ref. 23].

The capabilities are resident in the Tactical Communications Control Facilities (TCCF) concept developed by the TRI-TAC program [Ref. 24]. The model, however, is not TRI-TAC dependent since the TCCF concept, from a cost-benefit and employment point of view, does not necessarily meet Marine Corps requirements. Indeed, considerable doubt exists as to the viability of the TCCF concept. Clement proposes suspension of the program

> "...a separate program should be established to develop a computer based control system for use by a single manager who can monitor and automatically direct trunking and routing orders from a single console..." [Ref. 25].

Procurement of equipment with the required technology will require a judicious compromise of system design capacity and flexibility against the ultimate master of cost. No amount of determining of deficiencies or setting of requirements will bear fruit unless funds are available and allocated to fill the requirements.

With this in mind, procurement must be accomplished in such a manner that total life cycle costs (LCC) represent only a small portion of the total costs of the designated C^2 systems they support. By capitalizing upon the rapidly increasing power of recent vintage minicomputer based systems, together with the careful choice of a fully upward compatible family of equipments, the objective of automation and performance monitoring can be met.

Modularization of automated management and control systems through minicomputers clearly presents a lucrative and less expensive alternative, particularily when compared to the Communications Nodal Control Element (CNCE) of the TCCF concept [Ref. 26]. TRI-TAC envisions two versions of the CNCE, AN/TSQ-111(V)I and AN/TSQ-111(V)III; both highly expensive and both with design features and overall capabilities vastly exceeding Marine Corps requirements.

Nodal control capabilities through the Marine Corps switched networks require functional capabilities and intra-operability requirements in that they must utilize common hardware and software, but they do not require identical capabilities. For example, communications nodes at regimental and group level terminate and control far fewer circuits and fewer sophisticated and varied transmissions equipments than found at division of MAF level. The ability to tailor nodal control agencies to the echelon of command they serve with standardized hardware and software modules will

substantially increase flexibility in meeting the mission, and subsequent network configuration, requirements.

2. Hierarchial Levels

The current structure of communications control, Figure (13), can be utilized as a base to build hierarchial management levels required for effective operation and control. An over-all network manager can be integrated into the staff of the MAF communication-electronics office under the systems planning and engineering function. Operational network control can be envisioned as a function of Operational Systems Control at the MAGTF headquarters with an alternate agency established at division for backup purposes. Network management at other command echelons will be through local nodal control agencies provided by the communications battalions. Nodal control and equipment control can be envisioned as subsets of the technical control functions of communications control. Nodal control will be the responsible agency for overall nodal performance and will provide the management control over all personnel and equipment supporting nodal interconnectivity with the network.

The management and control requirements can be differentiated into four hierarchial levels: (1) Network Manager, (2) Network Control, (3) Nodal Control, and (4) Equipment Control.

a. Network Manager

The Network Manager oversees and is responsible for effective operation and performance of the overall network. Responsibilities of the Network Manager encompass broad system planning and network engineering functions. As previously stated, the system planning must be done in conjunction with supported unit communications officers and with the requirements of the tactical mission driving communications needlines.

The functions of the network manager present a radical departure from the present communication control system in that a greater involvement in the day-to-day management and control of the network will be required of the MAGTF Communications-Electronics Officer. Real-time information concerning network status will be available through the shared data base of the Network Control Agency to meet the network manager's increasing information requirements.

Acting as the network "czar" for the MAGTF commander, the network manager will have authority in resolving conflicts with local commanders over network operation and performance and has sole authority for directing major system modifications. The major responsibilities of the network manager include:

(1) Develop, maintain, and analyze resources and requirements data base.

(2) Plan, engineer, and analyze system configuration and interface.

(3) Develop implementation plan and issue taskings.

(4) Monitor implementation, testing, and system performance.

(5) Establish network priorities and contingency plans.

(6) Coordinate system interface with external agencies.

The plans, data, and taskings resulting from the exercising of these functions are promulgated to the Network Control Agency for action.

b. Network Control

The management functions performed by the network controller in response to directives from the Network Manager and network status data include.

(1) Issuing implementation and installation orders.

(2) Monitoring system performance and status.

(3) Traffic control management.

(4) Transmission system routing control.

(5) Data base establishment and maintenance.

(6) Resources Management.

(7) Dedicated circuit network management.

(8) Directory control.

The network controller has jurisdiction of operational management and control over the overall network. The network control agency will develop detailed directives to exercise this responsibility. Directives will be transmitted to each Local Nodal Control (LNC) agency on a real-time basis

for implementation. The direct tasking of LNC agencies will be accomplished through the co-located network nodal control agency.

A primary management function for Network Control will be monitoring the performance of the deployed network and analysis of traffic flow and processing loads at each LNC. It receives this information on a real-time basis from the Network Nodal Control. In the event of system stress, network disruption, or dynamic reconfiguration of the tactical forces, Network Control will develop plans to redirect the communications flow as necessary to satisfy essential command requirements and communications needlines.

Network Control will build-up and maintain a data base containing the status of all communication nodes and equipment deployed throughout the network. This data base must reflect up-to-date performance data of all nodes, links, and equipments comprising the network. The data base will be shared with the Network Manager to support and facilitate the network planning and engineering function; and, on a real-time basis with the alternate Network Control for emergency control transfer.

c. Nodal Control

The communications facilities and personnel deployed at a communications node and located at various command levels will be managed and controlled by the Network Nodal Control Agency. Local Nodal Control (LNC) implements

directives and instructions received from Network Control. LNC is responsible for the interface between the node and its communications-electronics environment. This includes the trunking interfaces with other nodes, interfaces with local switching facilities, and interfaces with subordinate nodal control agencies.

Local Nodal Control will provide the technical backbone of the network. As such, it will collect status data and communication performance data from all equipment and assemblages under its jurisdiction. Data will be collected via telemetry and data channels, and will be automatically processed to present the technical controller with real-time information about the overall nodal performance and provide for immediate localization of equipment failures and long term trends in performance and traffic patterns. These reports will be summarized and forwarded on a real-time basis to Network Nodal Control and passed to Network Control for inclusion in the Network Manager/Network Controller data base.

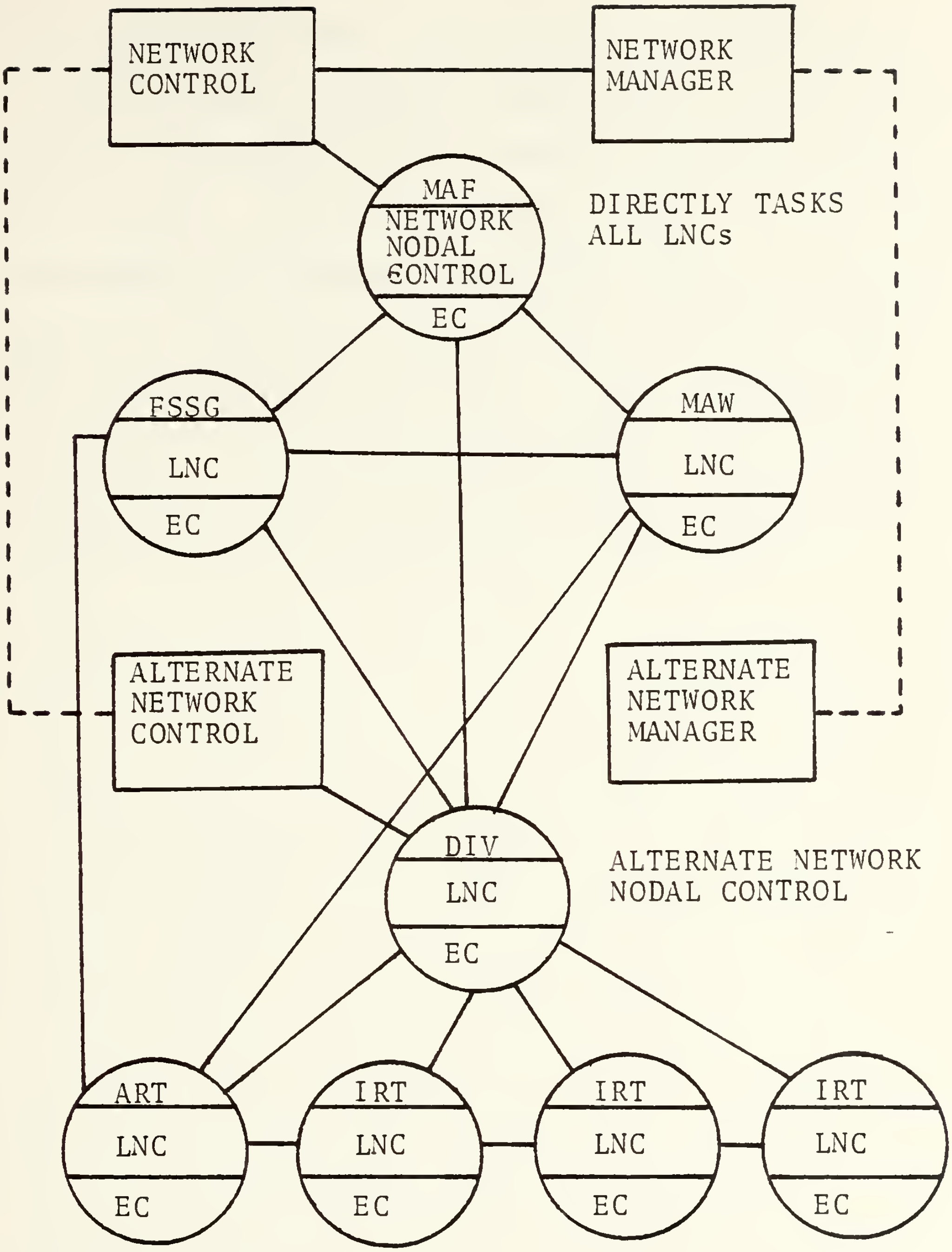
d. Equipment Control

Communications equipment envisioned with this model will be provided with organic monitoring and test function capability. Individual equipment components or modules will generate status and performance data for transmission to Local Nodal Control. Single purpose equipment, such as multiplexing units, will provide for a one-way

transmission of data to Nodal Control. Modules in larger, more sophisticated equipment such as circuit and message switches, will transmit equipment control data to Local Nodal Control and will also receive control signals to redirect test procedures or request more detailed performance or test data of specific components.

3. The Model

Figure (15) is a conceptual model representing a proposed centralized management and control scheme. The Network Manager, in his systems planning and engineering role, exercises operational control over the automatic switched network through the Network Controller. The Network Controller monitors the performance of the deployed network and manages and controls, through Network Nodal Control, subordinate Local Nodal Control agencies disperses throughout the network at different command levels. Local Nodal Control exercises technical management of all transmission and switching systems providing network interconnections at a particular communications node. Each of the transmission and switching facilities has built-in self-diagnostic, trouble-shooting capability which is provided automatically to Local Nodal Control. This information is utilized by the Local Nodal Control agency for technical management and performance monitoring purposes and is passed to Network Nodal Control and fed into the Network Controller's data base.



LNC = Local NODAL Control
EC = Equipment Control
----- Management Control Links
——— Network Control Links

Figure (15) A Network Management And Control Model

Built into the model is the basic requirement for network survivability and redundancy. Doctrinally, the senior ground element in the MAGTF takes command should the MAGTF headquarters become a casualty. In this event, or any other scenario where the MAF becomes inoperable, duplicate management agencies with duplicate capabilities at the division headquarters will automatically take control. Redundant links are provided for alternate routing for uninterrupted flow of information in the case of key node destruction.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The Impact Of MTACCS On Communications

The transition from a predominately manual, dedicated, and largely independent communications subsystem to a modern, automatic switched system will require major modifications in today's approach to the communications control function. The goal of achieving network flexibility and responsiveness for command and control systems such as MTACCS requires a dynamic management and real-time control scheme for optimal network performance. For example, the communications control hierarchy must permit rapid network reconfiguration under stress and must provide the greatest degree of network connectivity and reliability permitted by the tactical situation. Careful attention must be given to continuous network performance assessment to provide the service required by tactical computer systems. This assessment can only be attained through automation of the communications control hierarchy.

Communications supporting the MTACCS systems can no longer be considered a system with the primary purpose of supporting command. Rather, command will become a function of the MTACCS computer systems through inputs from the commander. The dependence of MTACCS on an integrated communications system for information transfer necessitates the

independence of the switched networks. Tactical commanders will be provided fast, secure, reliable, and efficient communications from which to command and control their forces. This will be provided at the cost of losing their perogative to utilize communications assets that interface their command nodes.

2. The Impact Of MTACCS On Command And Control

Command and control enhancements and degradations created by MTACCS can be categorized into two functional areas, operations and maintenance. The credentials of MTACCS suggest greatly improved support of tactical operations. Commanders will receive real-time information to improve the timeliness of decision making.

A profound impact will be in the manner that MTACCS performs the command and control functions. The previous method of voice and narrative record traffic will be replaced by computer to computer exchange through inputs by the commander in the case of the command function and largely through query/response and automatic routing in the case of the control function. The control function will be information dependent and will constitute the bulk of MTACCS real-time data. This demand impacts directly on the communications system since data transfer will only be as successful as the supporting communications system.

Technologically, there will be an influx of highly sophisticated computers, data storage and display devices.

This increase in operational effectiveness will require changes in manpower requirements (new skill and skill levels), and increased training for users. Maintenance requirements should not be a factor as long as external maintenance support remains available and responsive. Correlating external maintenance support to the requirement for increased mobility and dispersion of maneuver elements creates a coincidental demand for greater coordination on the part of the user.

B. RECOMMENDATIONS

1. Improved Network Management And Control

The model for network management and control developed in Chapter IV of this thesis provides only those functions that are considered as minimum essential. Other functions and capabilities should be added in an evolutionary manner, and the definitions of these functions and capabilities should be given high priority in the evolution of a network management and control design. Additional man-machine experimentation is necessary to identify major improvements that should be made to network management and control hardware and software. An optimal scheme for the dynamic rerouting of essential traffic around jammed links and damaged nodes is a high priority item for maintaining and improving network performance.

Beyond improvements to the network management and control model, distributing the network control functions widely throughout the MAGTF holds promise for improving

survivability against direct attacks on network management and control agencies. Major advances in microprocessors suggest that extensive control capabilities could be installed at many locations. Dispersing network control functions (especially those not requiring manual intervention) would allow the network to continue operation even after many of its nodal control points have been destroyed. Such a distributed system would naturally be constrained by the cost of the processors and advanced training required for management and operational personnel.

2. Improved Network Configuration

Even with the introduction of major changes in the currently planned TRI-TAC switches, additional survivability could be obtained by modifying the TRI-TAC routing plans to make them more flexible and more adaptive to a dynamically changing tactical network. In their discussion of TRI-TAC envisioned routing plans, Brick and Ellersick [Ref. 27], assert:

> "Increasing the number of alternate routes available at the originating switch, and selecting alternate routes that are not all dependent on one or two critical links, would improve network performance in a battlefield environment."

These routing plan changes will become more viable and more advantageous when the TRI-TAC developed digital equipments become the predominant equipments in the Marine Corps' inventory. More adaptive routing procedures will have the additional benefit of making the network less vulnerable to the loss of network control and nodal control agencies.

C. SOME FINAL THOUGHTS

The planned programs and concepts envisioned by the LFICS architecture will certainly enhance the information exchange capability for command and control requirements. Even after these programs have been implemented, the Marine Corps communications manager will still face a myriad of problems that LFICS does not solve. Consideration of the following factors are a necessity on any future battlefield: the increasing intention of battlefield commanders to attack the communications links and nodes of their adversaries; the increased capability of enemy electronic warfare and anti-radiation missiles; and the increasing emphasis on providing a mobile command and control capability.

These problem areas can be reduced, and perhaps eliminated, in the 1990s by taking advantage of opportunities that exist in several forms: technology improvements, system improvements/modifications, and joint service cooperation.

Recommendations for eliminating or reducing the remaining problem areas are as follows.

1. Reduce unintended radiation in unintended directions: concomitantly, reduce reception of undesired radiation from unintended sources and directions.

2. Make the friendly signals and sources less identifiable and less detectable by burying them in the natural background as much as possible, by putting them in a frequency region the enemy is not capable of detecting (because of propagation characteristics), or, if possible, by not radiating them.

3. Make the communications system more distributed and redundant, with fewer critical nodes and more backup links.

4. Deny the enemy the capability to attack communications nodes by denying him location information, spreading out the source so it is not an attackable target, deceiving him with false or disguised signals and targets, or turning off the source at critical times.

5. Make the communications system rapidly reconstitutable when parts are destroyed.

6. Secure the system by making the transmitted signals as undecipherable as possible, making access to the system impossible, and making the system immune to signal penetration.

7. Provide more capability to discriminate between undesired and desirable signals by frequency, time, waveform, and direction of arrival.

This is not intended to be a forecast of what will happen, but rather an indication of what could be done to overcome problems that exist after implementation and fielding of the equipment provided by the LFICS architecture.

APPENDIX A

ABBREVIATIONS AND DEFINITIONS

AADCCS	Army Air Defense Command and Control System
AADCP	Army Air Defense Command Post
A/C	Aircraft
AFSATCOM	Air Force Satellite Communication
AMU	Alternate Master Unit (PLRS)
ANDVT	Advance Narrowband Digital Voice Terminal
AOA	Amphibious Objective Area
ART	Artillery Regiment
ASCII	American Standard Code for Information Interchange
ASRT	Air Support Radar Team - A mobile unit equipped with precision radar to provide all-weather guidance for tactical strike aircraft attacking ground targets
AT&T	American Telephone and Telegraph Company
AUTODIN	Automatic Digital Network
AWACS	Airborne Warning and Control System
BASEBAND	In a carrier (or subcarrier) wire or radio transmission system, the band of frequencies occupied by the signal before it modulates the carrier (or subcarrier) frequency to form the transmitted or radio signal.
BAUD	The unit of modulation rate. One baud corresponds to a rate of one unit interval per second, where the modulation rate is expressed as the reciprocal of the duration in seconds of the smallest unit interval. Example: If the duration of the unit interval is 20 milliseconds, the modulation rate is 50 bauds.

BN	Battalion
C^2	Command and Control
CAP	Communications Access Processor
CATF	Commander Amphibious Task Force
CCP	Communications Control Panel
Channel	A communications channel is a single path between terminal points in a system. It may be unidirectional or bidirectional. It may traverse links and trunks which are single channel or multichannel. A channel is extended on each end by loops to form a circuit.
CEO	Communications Electronics Officer
CG	Commanding General
Circuit	An electrical path between terminals providing one-and two-way communications
CIC	Combat Information Center
COC	Combat Operations Center
COMMCON	Communications Control
COMMSEC	Communications Security
CRC	Control and Reporting Center (Air Force)
CRP	Control and Reporting Post (Air Force)
CSS	Combat Service Support
CUDIXS	Common User Digital Exchange System
DASC	Direct Air Support Center
DCE	Digital Communications Equipment
DCT	Digital Communications Terminal

Digital	A signal having discrete states such as the presence or absence of a voltage. The signal is given meaning by assigning numerical values or other information to the various possible combinations of the discrete states of the signal.
DS	Direct Support
DTG	Data Trunk Group
EC	Equipment Control
ECCM	Electronic Counter-Counter Measures
FAAD	Forward Area Air Defense
FAC	Forward Air Controller
FAC(A)	Forward Air Controller (Airborne)
FASC	Fire and Air Support Center
FASS	Fire and Air Support Section
FDC	Fire Direction Center
FDM	Frequency Division Multiplex
FM	Frequency Modulation
FMF	Fleet Marine Force
FMFM	Fleet Marine Force Manual
FLTSATCOM	Fleet Satellite Communications
FOC	Flight Operations Center (Army)
Frequency Hopping	A spread spectrum technique whereby the signal energy is spread over a large bandwidth by rapidly changing the carrier frequency in a pseudorandom manner.
FSK	Frequency Shift Keying
GS	General Support
GT	Gun Target

HC(A)	Helicopter Coordinator (Airborne)
HF	High Frequency
Hz	Hertz. A unit of frequency equal to one cycle per second.
IAC	Intelligence Analysis Center
IBN	Infantry Battalion
IHAWK	Improved Hawk
II	Imagery Interpretation
Interoperability	Interoperability is the capability of two elements (e.g., terminals, computers, switches to exchange mutually comprehensible information over communication links. Full interoperability requires three types of compatibility: electrical, protocol and operational. To be electrically compatible, the communication interfaces must use the same signal levels, transmission rate, frequency and modulation or digital encoding techniques. Protocol is the set of procedures used to control information transmission and includes error detection and correction techniques, mode of operation (e.g., full duplex or half duplex), coordination signalling (e.g., acknowledgments, start/stop directives, etc.) and sometimes code. Operational compatibility refers to the interpretation of the information by the sender, a mutual understanding of the meaning of the information elements (i.e., characters, words, symbols, etc.), and the actions which will be taken as a result of the interpretation of the information.
I/O	Input/Output
IP	Imagery Processing
IRT	Infantry Regiment
JTF	Joint Task Force
kbp/s	Kilo Bits Per Second

LAAM	Light Antiaircraft Missile
LCC	Life Cycle Cost
LFICS	Landing Force Integrated Communications System
Link	A portion of a communication circuit: a radio path between two points
Loop	In tactical switched communications, any single circuit from a switching center/ message distribution point to the terminals of an end instrument: the circuit that connects a subscriber to a switch
LOS	Line of Sight
LZ	Landing Zone
MACCS	Marine Air Command and Control System
MAF	Marine Amphibious Force
MAG	Marine Air Group
MAGTF	Marine Air-Ground Task Force
MATCALS	Marine Air Traffic Control and Landing System
MATCS DET	Marine Air Traffic Control Squadron Detachment
MAW	Marine Air Wing
MHz	Megahertz. One Million Cycles per Second
MU	Master Unit (PLRS)
NATO	North Atlantic Treaty Organization
NGF	Naval Gunfire
NIPS	Naval Intelligence Processing System
OSC	Operational Systems Control
OSCC	Operational Systems Control Center
PCM	Pulse Code Modulation

PLI	Position Location Information
PLPP	Position Location Post Processor
SACC	Supporting Arms Coordination Center
SHF	Super High Frequency
SINCGARS	Single Channel Ground Air Radio System
SYSCON	Systems Control
SPE	Systems Planning and Engineering
TAC(A)	Tactical Air Coordinator (Airborne)
TACC	Tactical Air Command Center
TACFIRE	Tactical Fire Direction Center (Army)
TADC	Tactical Air Direction Center
TAO	Tactical Air Observer
TCCF	Tactical Communications Control Facility
TDM	Time Division Multiplex
TECHCON	Technical Control
TECHCONFAC	Technical Control Facility
TOS	Tactical Operations System (Army)
TTY	Teletype
UHF	Ultra High Frequency
UU	User Unit (PLRS)
VHF	Very High Frequency
VMAQ	Marine Tactical Electronic Warfare Squadron
VMFP	Marine Tactical Reconnaissance Squadron

APPENDIX B

DESCRIPTION OF LFICS/MTACCS COMMUNICATIONS EQUIPMENT

A. SINGLE CHANNEL TRANSMISSION EQUIPMENT [Ref. 28]

1. Radio Set Family AN/GRC-( ) (SINCGARS)

The GRC-( ) is the Single Channel Ground Air Radio System (SINCGARS) radio, which will be the VHF FM equipment of the future. The GRC-( ) will contain a standard R/T unit that may be configured for portable, vehicular or aircraft installation by appropriate combinations of ancillary equipment. Channels are 25 or 50 kHz over the 30 to 80 MHz band. The GRC-( ) will provide COMMSEC (VANDAL and VINSON) and ECCM capability through frequency hopping/spread spectrum modulation schemes.

2. Bancroft TSEC/KY-67

The Bancroft is an integrated (16kb/s) VHF/FM secure digital voice radio set designed for manpack/vehicular use. It operates on any of 1,840 channels which are 25 kHz wide over the 30 to 76 MHz band. The Bancroft is compatible with VINSON secure voice radios through a built-in analog to digital conversion device.

3. AN/TYA-19 Data Communications Group

The TYA-19 is housed in transportable shelters and is a major unit of the Marine Air Command and Control System (MACCS) Beach Relay. It provides an HF radio link for data exchange between elements of the Marine Air Command and Control System (MACCS), the Naval Tactical Data System (NTDS), the Airborne Tactical Data System (ATDS), and other elements of the MACCS.

4. AN/TYQ-3 Tactical Data Communications Central

The TYQ-3 is used in tactical air operations. It provides capability and compatibility for interchange of data between Marine Air Command and Control System (MACCS) and Navy and Air Tactical Data Systems. It consists of the TYA-20 which provides data transfer compatibility, the TYA-19 which provides the communication links, the TYA-17 which provides multiplexing/demultiplexing and address control functions, and the TYA-24 which includes test equipment for the maintenance and repair of radio equipment in the TYA-19.

B. TERRESTRIAL MULTICHANNEL TRANSMISSION EQUIPMENT [Ref. 29]

1. AN/TRC-97C Radio Set

The TRC-97C is housed in a S-308A shelter and is basically an analog SHF troposcatter radio set with dual diversity, designed to provide two way communications of voice, digital data and TTY, with a like terminal. A variety of RF power modes can be selected to achieve optimum operation in the 1 to 100 mile range with single links, using LOS and obstacle gain diffraction modes of propagation, as well as the troposcatter mode. Longer distances can be achieved with tandem links, using the TRC-97 as a repeater station. The TTY multiplexer can be patched into any one of 12 voice frequency channels (300 to 3500 Hz) to provide a capability of 16 TTY channels along with a combination of 11 voice/data channels. The AN/TRC-97E provides a 24 voice I/O channel capability. The TRC-97 will be replaced by the GRC-201.

2. AN/GRC-201 Radio Set/AN/TCC-72 (MOD) Telephone Terminal

The GRC-201 is a modified TRC-97 which permits use of digital multiplexing and security equipment currently available or being developed. The modification consists of additional of dipulse-compatible modulation and detection circuitry. A 24 PCM voice channel capability is obtained when used with the TCC-72 which is a secure 24-channel telephone PCM multiplex terminal assemblage. It provides terminal multiplex equipment that can be used over either radio or cable facilities. It will provide the capability to handle 16 to 32 kbps digital channels as well as PCM voice channels.

3. AN/MRC(XXX) Digital Wideband Transmission System

The MRC(XXX) is a vehicular mounted integrated multichannel system providing two-way secure transmission. Two candidate systems are being evaluated. One providing 8 channels in the UHF range (1350-1850 MHz) and one providing 4 channels in the VHF range (30-75.95 MHz). Both will provide channel rates of 16/32 kb/s with a range of from 20-30 miles.

4. AN/TRC-(SINCGARS) Radio Set

The TRC-(SINCGARS) is being developed as part of the SINCGARS FAMILY of radios. It will be a VHF multichannel wideband radio set capable of transmitting up to four 16 kb/s channels.

5. AN/TRC-170(V)3 Troposcatter Radio Set

The TRC-170 is an SHF troposcatter radio terminal set being developed under the TRI-TAC Program. It is housed in a S-250 shelter and will provide the capability for transmission and reception of digital voice, analog voice, quasi-analog and digital data signals. Operational modes include internodal trunking, remote subscriber access, subscriber access at relay, dedicated trunking and multi-trunking over LOS and troposcatter ranges up to 100 miles. The voice orderwire (16 kb/s, half-duplex) is secured by a KY-58 and the data orderwire (2 kb/s, half-duplex) is sucured by a KG-84. Analog loops (4-Wire) are converted to digital by an analog applique unit. The TRC-170 will replace the TRC-97 and GRC-201.

6. AN/TSC-95 Communication System

The TSC-95 will provide more reliable and efficient long-haul HF communications, up to 12,500 miles, for a deployed MAGTF. Developmental efforts in the areas of high speed data modems and time diversity modems ensure that either the 2,400 baud TYC-5A Mobile Data Communications Terminal or lower speed teletypewriter circuits can be accommodated with significant performance improvement. The TSC-95 will be composed of a TRC-171, a shelterized HF communications central: and a TGC-46, a shelterized teletypewriter central. It will provide the capability for one secure voice and two full-duplex TTY channels.

7. AN/TYA-12 Communications Group

The TYA-12 provides circuitry for several different categories of communications. A manual telephone switchboard and telephone terminal assemblies provide voice communications between any combination of internal or external communications media. A master intercommunication station is located adjacent to the switchboard at the operator's station with a communications status panel. Equipment capability also includes reception and transmission of intercepter and missile battery data. Two radio sets (GRC-112 and GRC-134) with appropriate filters, antennas, and isolation and conversion modules provide some of the UHF radio links between the TAOC and other centers and aircraft.

8. AN/TYQ-1 Tactical Air Command Center

The TYQ-1 is used in tactical air operations. It consists of one operation group (TYA-1), one planning group (TYA-3), one communications group (TYA-16), and a maintenance facility group (TYA-28). It provides the tactical air commander with a computer support facility to assist him in the

decision making process required to plan and direct the over-all air battle. It also provides for communication with other systems and processing and correlation of data.

9. AN/TYQ-2 Tactical Air Operations Central (TAOC)

The AN/TYQ-2 (TAOC) is the subordinate operational element of the Marine Air Command and Control System designed for control of enroute air traffic and air defense operations including assigned manned interceptors and surface-to-air missiles. With direct inputs from organic radar sensors and by remote inputs from external air defense/air control agencies via digital data links, it detects, identifies and controls the intercept of hostile aircraft and provides navigational assistance to friendly aircraft in the accomplishment of support missions. Additionally, the TAOC functions as the alternate TACC/TAOC when directed. Specific functions include the automatic detection, acquisition, and tracking of friendly and hostile aircraft by computer processing of radar inputs; computer aided identification, classification and weapons assignment: computation of intercept parameters: transmission of intercept commands: and exchange of information to other systems by digital data links. The TYQ-2 consists of nine major groups. Central Computer Group, TYA-5; Data Processing Group, TYA-6; Geographic Display Generation Group, TYA-7; Operations Group, TYA-9; Communications Group, TYA-12; 3D Radar Processor Group, TYA-18; Unit Test Group, TYA-23; Photographic/Transport Group, TYA-25; Maintenance Group, TYA-27.

C. SATELLITE TRANSMISSION EQUIPMENT [Ref. 30]

1. AN/PSC-1 Portable UHF TACSATCOM Radio

The PSC-1 is a portable manpack UHF tactical satellite radio terminal that permits half-duplex burst communications via the AFSATCOM I transponder of FLTSATCOM. It is also capable of operating in the LOS mode.

2. AN/TSC-85A Satellite Communications Terminal

The TSC-85A is a nodal or point-to-point trunking terminal capable of transmission of a single multiplexed high data rate carrier (6, 12, 24 or 48 channels) and reception of one to four independent carrier frequencies (6, 12 or 24 channels). The transmission rate per channel is 48 kb/s PCM. The TSC-85A hub terminal can simultaneously communicate with up to 4 TSC-93A spoke terminals. In addition to the multi-channel traffic transmission mode, the TSC-85A also provides an order-wire (off-line and on-line) and a single channel secure voice

transmission mode. In the secure voice mode, all other modes are inhibited permitting transmission and reception of a single 16 kb/s digitized voice channel.

3. AN/TSC-93A Satellite Communications Terminal

The TSC-93A is a non-nodal or point-to-point terminal capable of transmitting or receiving on a single carrier 6/12/24 PCM channels. The transmission rate per channel is 48 kb/s. In addition to the multi-channel traffic transmission mode, the TSC-93A also provides an orderwire (off-line and on-line) and a single channel secure voice transmission mode. In the secure voice mode, all other modes are inhibited permitting transmission and reception of a single 16 kb/s digitized voice channel.

4. AN/TSC-96(V) Satellite Communications Central

The TSC-96 consists of the OZ46 and OL4188. The OZ46 Radio Set Group is the Landing Force Transmit and Receive Subsystem terminal of the FLTSATCOM system. It consists of three UHF satellite transceivers, antenna system, line interface units and ancillary equipment. Each transceiver provides half-duplex satellite radio channels for voice, data and TTY. The OL-188 Data Processing Group contains the voice data and TTY terminal equipments and COMSEC equipments to terminate the 1200 b/s Fleet Broadcast Channel to enter the FLTSATCOM secure voice network, and to become a CUDIXS subscriber.

D. SWITCHING EQUIPMENTS [Ref. 31]

1. AN/TTC-42 (V)1 and (V)2 Automatic Telephone Central Office

The TTC-42 is the 150-line member of the unit level circuit switch (ULCS) being developed as part of the TRI-TAC program to provide automatic switched telephone service to primarily digital secure and non-secure terminals. The TTC-42 terminates up to 7 CX-11230 cables and eleven 26-pair WM-130 cables. It provides sole user and switched service for up to 150 channels, which can consist of up to 96 digital or analog channels and up to 144 channels derived from TDM groups. It has a seven digital trunk group (DTG) capacity, six DTGs with up to 18 channels (16/32 kb/s) per group, and one DTG with up to 72 channels per group. Digital loop modulation is conditioned diphase, and digital trunk modulation is conditioned diphase or conditioned dipulse. Automatic switching includes loop-to-loop, loop-to-trunk, trunk-to-loop, and trunk-to-trunk. Analog switching can be automatic or

semi-automatic and analog to digital conversions are provided as required. Subscriber service functions include loop and trunk hunting, conferencing (progressive-up to 5 conferees), direct subscriber access, abbreviated dialing, precedence, pre-emption, and fixed directory. The TTC-42 performs multiplexing and a limited amount of technical control functions.

2. SB-3865 ( )(P)/TTC Automatic Telephone Switchboard

The SB-3865 is the 30 line member of the unit level circuit switch (ULCS) family being developed as part of the TRI-TAC program to provide service to primarily digital secure and non-secure voice terminals. It terminates 32 single channels and 4 order wire channels via 36 WF-16 cables, and 3 TDM groups via 3 CX-11230 cables. It provides user and switched service for up to 30 single digital or analog channels and up to 18 channels (16/32 kb/s) derived from TDM groups. Automatic switching includes loop to loop, loop-to-trunk, trunk-to-loop, and trunk-to-trunk. Analog switching can be automatic or semi-automatic, and analog to digital conversions are provided, as required. Digital trunk/terminal subscriber service functions include loop and trunk hunting, precedence, and pre-emption. The SB-3865 performs a limited amount of multiplexing and technical control functions.

3. AN/TYC-11 Automatic Message Switching Central

The TYC-11 is a 12-line message switch which includes control and management facilities for the operational control of self-contained TYC-11 and GYC-7 subnetworks as well as for individual TYC-11s. It is being developed as part of the TRI-TAC Program (MRTT Family) to provide austere-store-and-forward service of both record and data traffic to a variety of connected terminals and to other digital switches. It terminates WF-16 cable, 26-pair cable, and CX-11230 coaxial cable to provide 12 traffic access channels and 2 traffic attendant/supervisory channels. Access circuits are employed as a flexible mix of dedicated loops, trunks, and interface circuits as well as switched loops. Trunks are encrypted, dedicated loops can be encrypted or approved, and switched loops can be encrypted. Access circuit modulation includes conditioned diphase for dedicated loops and trunks and switched loops, and Non-Return-to-Zero (NRZ) baseband for dedicated loops and trunks. The TYC-11 has an intransit storage capacity of 250 (2400 characters) messages.

4. AN/GYC-7 Automatic Message Switching Set

The GYC-7 is the 12-line version of the unit level message switch (ULMS) family being developed as part of the TRI-TAC program to provide austere store-and-forward service of data traffic to a variety of connected terminals and other

digital switches. It employs mode VII link protocol in the transmission and reception of data over all dedicated access circuits used as loops. It terminates 12 traffic access circuits and one operator terminal access circuit via 13 WF-16 four-wire cables. Access circuits are dedicated, synchronous full-duplex encrypted or non-encrypted, and employed as a flexible mix of loops and trunks. Access circuit modulation is conditioned diphase and the transmission rate is 16 or 32 kb/s with an information rate of 16 kb/s or 8 kb/s with forward error correction. Operator terminal access circuit modulation is NRZ baseband and the information/transmission rate is 1200 bp/s. The GYC-7 has an intransit storage capability of 64,000 bytes.

E. TERMINAL DEVICE EQUIPMENT [Ref. 32]

1. AN/PSG-( ) Digital Communications Terminal (DCT)

The PSG-( ) is a source automation device that allows the users to transmit, receive, edit, display, and review preformated, graphics, and free text messages. These devices will be used throughout the communications system and with tactical data systems.

2. TA-954( )/TT,TA-984( )/TT Digital Nonsecure Voice Terminal (DNVT)

The DNVT will be utilized with the TRI-TAC family of switches to provide a digital non-secure complement to the digital secure voice telephone. The TA-954 is ruggedized for use in a military field environment while the TA-984 is designed for use in the sheltered environment. The transmission and information rates are 16 and 32 kb/s, with conditioned diphase modulation. The 4-wire loop interface consists of a transmit pair and a receive pair which carry digital signals and provide the dc phantom path for common battery power.

3. AN/TYC-5A Data Communications Terminal

The TYC-5A is a shelterized Mode 1 Autodin terminal. It provides secure 1200/2400 b/s duplex operation with automatic error and channel controls allowing independent and simultaneous two-way operation. Control characters are used to acknowledge receipt of valid line blocks and messages or to return error information to an AUTODIN switch or other Mode 1 terminals. The TYC-5A includes an AUTODIN interface Unit which provides control and coordination between the AUTODIN tributory line and the input/output devices, a Magnetic Tape capability, a Card Reader/Punch subsystem which reads and punches 80 column Hollerith cards containing the

transmitted and received message traffic, a Paper Tape Reader/Punch which reads and punches 5 and 8 track paper containing the transmitted and received message traffic, and a printer subsystem which simultaneously print selective hard copy of both transmitted and received message traffic.

4. AN/UGC-74 Modular Input/Output Terminal

The UGC-74 provides users with an on-line capability to interface with the unit level message switches or the transmission system. It consists of a keyboard, printer, processor and memory. The unit is capable of storing up to ten pages (16,000 characters) of data and provides prompting and editing features to facilitate original message composition. It provides for ASCII (up to 1200 baud) or baudot (up to 75 baud) full-duplex operation, and communications interface with conditioned diphase or NRZ signals. It has an average printing speed of 120 characters per second.

5. AN/UXC-4 Tactical Digital Facsimile

The UXC-4 is being developed under the TRI-TAC program to provide rapid and encrypted transmission and reception of low resolution picture elements. It is capable of operation with transmission rates up to 16 kb/s via wire and radio channels through existing COMSEC and modem equipment, and via 16 and 32 kb/s TRI-TAC channels using primarily the digital secure voice terminal. The transmission time at 16 kb/s for an 8 1/2 by 11 inch document is 30 seconds. The UXC-4 can handle transmission copy 5 to 9 inches wide, 3 to 36 inches long and 0.002 to 0.020 inches thick, and recording copy 8.5 to 8.75 inches wide. The UXC-4 can operate in the half-duplex, full-duplex or receive only mode.

6. Digital Communications Equipment (DCE) [Ref. 33]

The operational employment of MTACCS tactical data systems will require interfacing with a variety of tactical communications equipment. The tactical communications equipment will require that a variety of hardware interfacing devices and COMMSEC devices be provided by or for the tactical data systems to ensure secure, reliable communications. The DCE as depicted in Figure (16) will include the buffers required for speed conversion or for parallel to serial conversions, the hardware encryption devices if required, and the hardware modems used to convert computer logic level signals for transmission over radio and wire systems.

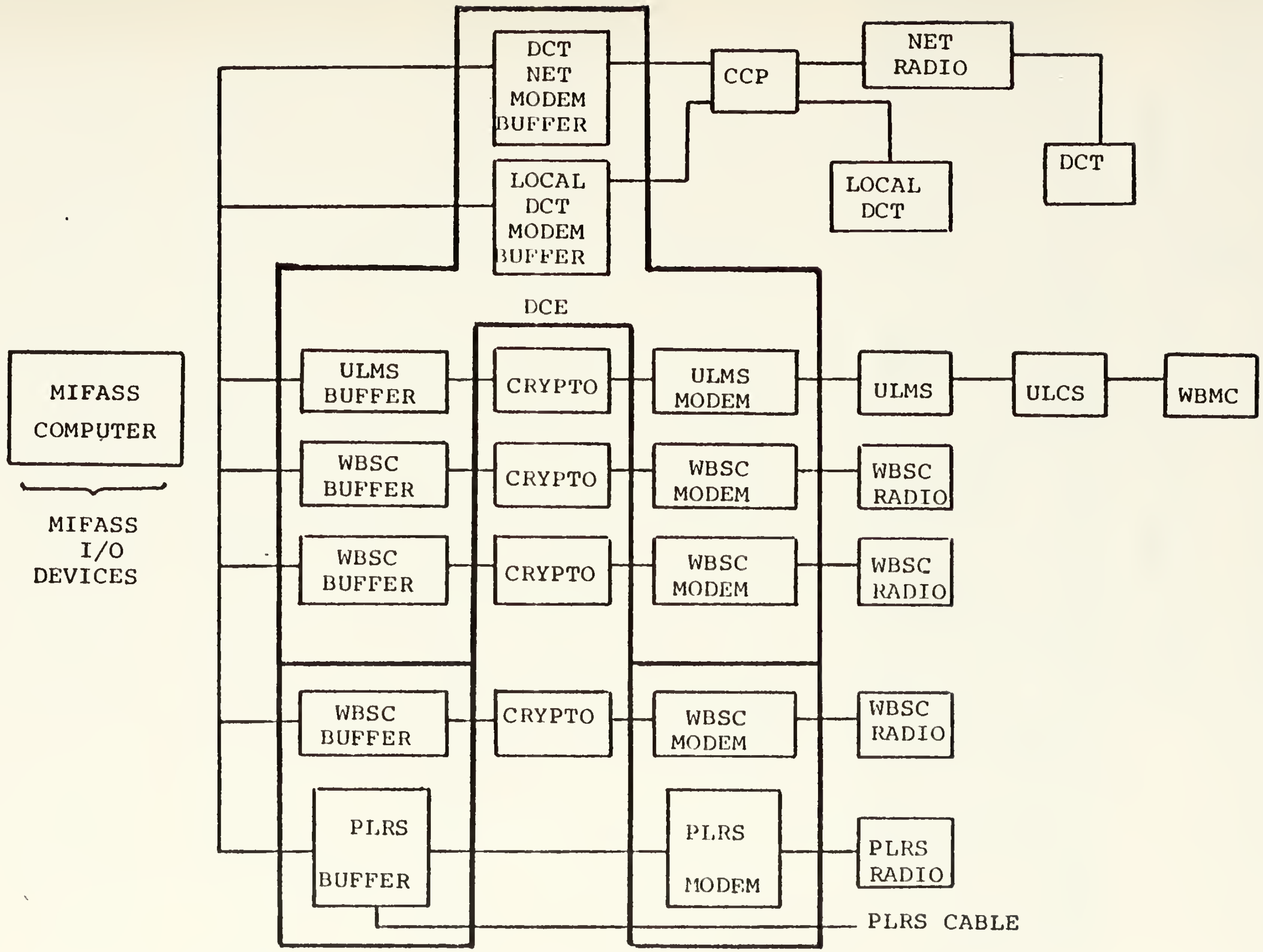


Figure (16) Digital Communications Equipment (DCE)

The net portion of the DCE will provide modem/buffer capabilities to net and local DCTs. The trunk portion of the DCE will provide modem/buffer capabilities to the ULMS, several wideband single channel full duplex radios. The DCE, in the case of MIFASS, will also have the capability to provide the interface with PLRS.

7. Communications Control Panel (CCP)

The CCP is the MTACCS tactical data system operator's intercomm and interface with the Landing Force Integrated Communications System (LFICS). The voice communications media that terminate at the CCP include a mix of HF, VHF, and UHF radios, tactical circuit switches, tactical message switches, and the intercomm system. The telephone and radio circuits may be secure or non-secure. The CCP provides the capability to connect a DCT in order to transfer digital data.

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